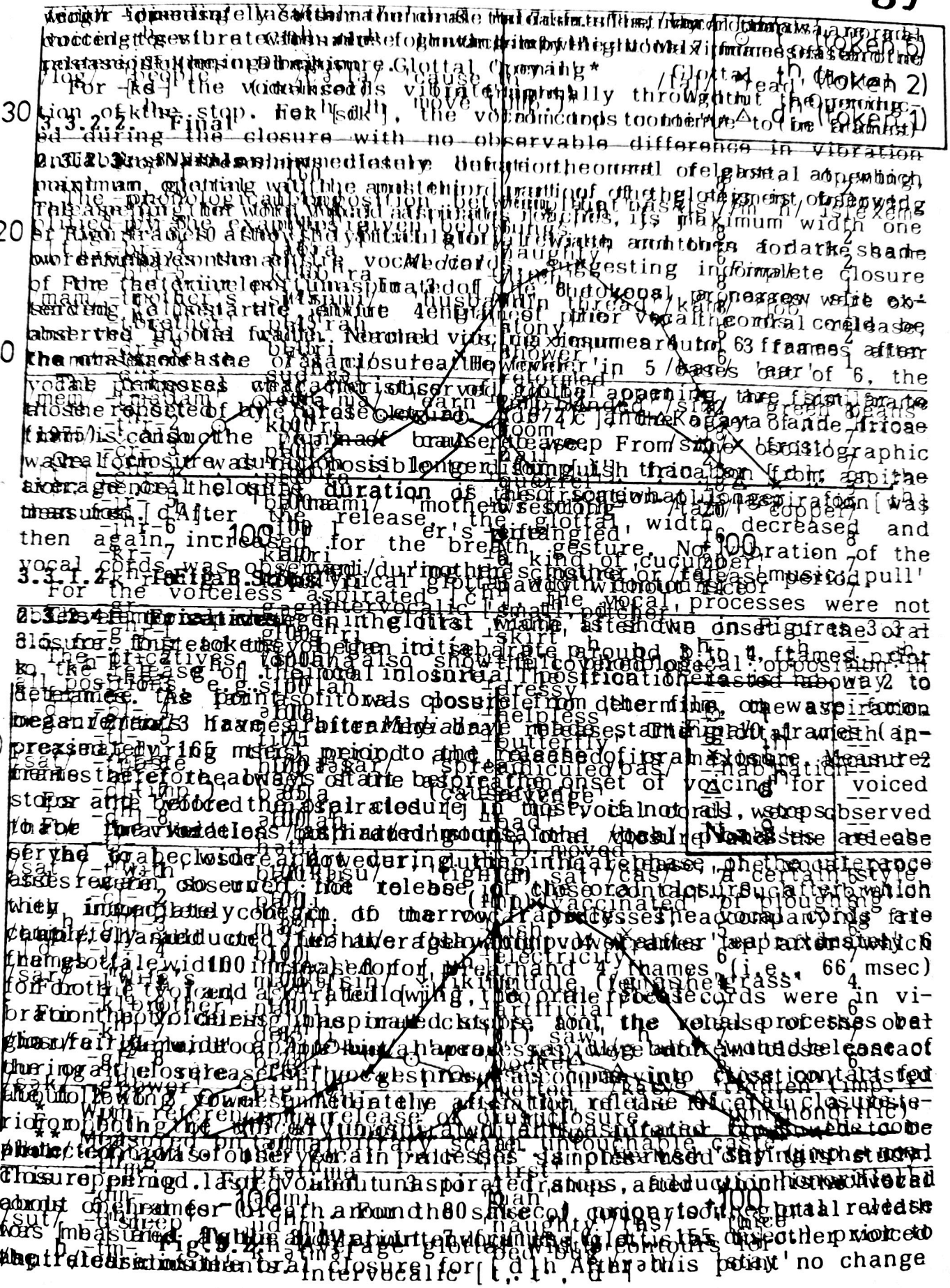

Fig. 3.4

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Maithili

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Ramawatar Yadav

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To my father

śrī Prabhu Yadav

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PREFACE

This book is the first full-length phonetic study of Maithili – an Indo-Aryan language spoken in Nepal and India. The study is based entirely on the pronunciation of the author who is a native speaker of Maithili and was born in the village of Muriba, near the town of Janakpur in the *Tarai* of Nepal. The experimental methods used in this study are mainly acoustic and fiberoptic in nature.

It is unfortunate that the study of Maithili has not received the attention it deserves, even in the areas where it is spoken as a native language. The publication of this book, it is hoped, will enliven interest in further serious linguistic studies of this language in future.

This book is a corrected version of a doctoral dissertation submitted to the University of Kansas, U.S.A. in 1979. Grateful thanks are due to the members of my dissertation committee, Robert L.Rankin and Michael M.T. Henderson, and to my supervisor Frances Ingemann for help, guidance, and encouragement. I am also grateful to the Haskins Laboratories, New Haven, Connecticut, for providing me with the opportunity to do the fiberoptic study, and especially to Katherine Harris, Thomas Baer, and Seiji Niimi for help in research design and interpretation of data; and to John Michael, Bureau of Child Research, University of Kansas, for help in analysis and measurement of the fiberoptic data. Grateful thanks are also due to the IIE, New York, for granting me a Fulbright-Hays scholarship from Fall 1974 through Summer 1979.

My warmest thanks and gratitude are due to Jörn H. Kruhl, to whom no detail was too small and no labor too heavy. He not only prepared the excellent typescript but also saw the book through the press.

Mainz, June 29, 1984 RAMAWATAR YADAV

1 INTRODUCTION

1.1. THE LANGUAGE AND THE AREA

Maithili is a New Indo-Aryan (NIA) language written in the Devanagari[1] script. It is spoken by a total of about 21 million people in the eastern and northern regions of the Bihar state of north India and the southeastern plains, known as the Tarai, of Nepal. In the past, Maithili was regarded either as a dialect of Bengali (Beames 1872-79/reprint 1966:84-85)[2], or of Eastern Hindi (Hoernle 1880), or as one of the three dialects of a spurious language called 'Bihari' (Grierson 1883-87; 1885; 1903/reprint 1968). Today, however, it is recognized as a distinct language and taught as such in the Indian universities of Calcutta, Bihar, Patna, Bhagalpur, Darbhanga and Benares, and the Tribhuvan University of Nepal. Demographically, Maithili is the second most widely spoken language of Nepal[3], and, according to the International P.E.N. (Poets, Essayists and Novelists) and the *Sahitya Akademi* (National Academy of Letters), the 16th largest language of India. As early an investigator as Grierson (1883a:1) recognized the distinctiveness of Maithili:

> ...for though, doubtless, Hindí and the dialects herein treated of may ultimately be traced up to a common parentage, this point of departure is so extremely distant, and the stems of these languages have developed and branched off so luxuriously in different directions, that they have nothing in common, but their roots.

1.2. A BRIEF SKETCH OF IMPORTANT WORKS ON MAITHILI

References to Maithili (then spelt *Mithelee* or *Mythili*) as a language date back to as early as 1801.[4] However, serious interest in Maithili linguistics began in the early 1880's when Sir George Abraham Grierson and A.F.Rudolf Hoernle published a series of scholarly books and papers on Maithili. In 1880, Hoernle published a book entitled *A Comparative Grammar of the Gauḍian Languages, With Special Reference to Eastern Hindi*, in which he treated Maithilí as a dialect of Eastern Hindi. Hoernle, however, did recognize the fact that Maithili exhibits more "unmistakable similarities" ('Introduction', 1880:viii) to Bengali and Nepali than to Hindi. He observed:

> ...Indeed, I am doubtful, whether it is more correct to to class the Maithili as a Bangálí dialect rather than as an E[astern] H[indi] one. Thus in the formation of the past tense, Maithili agrees very closely with Bangálí, while

it differs widely from the E.H. - ('Introduction' viii-ix)

In 1881, Grierson published *An Introduction to the Maithili Language of North Bihar*, Part 1 'Grammar' (henceforth *Introduction*). The *Introduction* is the most complete synchronic description of Maithili to date. It is divided into four parts-- part I deals with the alphabet and pronunciation; part II deals with nouns, adjectives and pronouns; part III discusses the verb in detail; and part IV discusses the "indeclinables", i.e., adverbs, prepositions, and conjunctions. The description, however,is based heavily upon Maithili forms obtained from translations of Hindi and Sanskrit forms by "the Pundits, Village School Masters and educated Native Gentlemen of Northern Mithila..."(p.1). In 1882, Grierson published part II ('Chrestomathy and Vocabulary') of the *Introduction*. The 'Vocabulary' is perhaps the earliest word-list of the Maithili language and contains all the words occurring in the *Chrestomathy* of the greatest Maithili poet, Vidyapati (1360-1448), besides "a large number of words collected by me in the country and in Court, and not hitherto found in dictionaries" ('Prefatory Note':125). The major contribution of Grierson, however, lies in the very extensive dialectal survey of what he called Bihari, published during 1883-1887 as the *Seven Grammars of the Dialects and Subdialects of the Bihari Language* (part I 'Introductory'; part II 'Bhojpuri Dialect'; part III 'Magadhi Dialect'; part IV 'Maithili-Bhojpuri Dialect'; part V 'South Maithili Dialect'; part VI 'South Maithili-Magadhi Dialect'; part VII 'South Maithili-Bangali Dialect'; and part VIII 'Maithili-Bangali Dialect'). During this period, there also appeared Hoernle and Grierson's *A Comparative Dictionary of the Bihari Language* (part I 1885; part II 1889; only two parts published). A consummate summary of all the major findings was later published as 'Indo-European Family Eastern Group: Bihari and Oriya Languages' in Grierson's (1903/reprint 1968) *Linguistic Survey of India* 5:2.

What is curious is that in spite of Grierson's tireless efforts to establish Maithili as a language separate from Bengali and Hindi, Kellogg (1893) continues to treat Maithili as a dialect of Hindi. The importance of Kellogg's work lies in the copious illustrations from Maithili, coupled with insightful philological notes.

In 1958, S.Jha's *The Formation of the Maithilī Language* appeared. It is the most exhaustive diachronic description of Maithili. In it, Jha has undertaken to trace the history of Maithili from the Old Indo-Aryan (OIA) period and has labored assiduously to assign Sanskrit etymologies to practically all forms of Maithili (for a contrary view, emphasizing the Santhali, i.e., Munda, influences on Maithili, see De Vreese, 1962).

In recent years, a number of Sanskrit grammars, masquerading as Maithili grammars, have been published in north India. A two-volume history of Maithili literature has also been published by

Mishra (1949, 1969a).

In Nepal, linguists from the Summer Institute of Linguistics have recently published two papers on Maithili syntax, both written in the tagmemic framework (Davis 1973; Williams 1973), and a word-list (Trail 1973). A *paryāyavācī śavdakoś* (Dictionary of Synonyms) of 14 languages of Nepal, including Maithili, has also been published by the Royal Nepal Academy (B.S. 2030/1973-1974).

1.3. A NOTE ON THE TERM 'BIHARI'

Since it is customary among Western linguists to refer to Maithili as 'Bihari', a few words on this term are in order. The earliest usage of the term 'Bihari' (literally, the language of Bihar) is found in Grierson (1883a:2), wherein he offers the following reasons for adopting this name to designate three dialects -- Bhojpuri, Maithili and Magadhi [Magahi]:

> (1) It is a local name, like the names of languages, as Bangálí, Panjábí, &c.
>
> (2) The extension of the name to cover all the dialects of Eastern Hindústán has a parallel in the case of Maráṭhí, which has been extended to cover the Dakhaní dialect of Berár, while it means literally only the dialect of the Maráṭhá country.
>
> (3) There is a historical propriety in the name, as the word Bihár is derived from the Buddhist *Viháras* or monasteries, once so thickly spread over that region; and Bihárí in its most ancient form was the language of the early Jains and Buddhists.
>
> (4) Bihárí has a prescriptive right to the dignity of assuming a general character, for the only one of all the dialects of Eastern Hindústán which possesses any literature is Maithilí, a dialect of north Bihár.

That the choice was unfortunate has been felt ever since. Most modern writers on Maithili (Mishra 1949:55-57; 1969b:270-71 and G.Jha 1974:29-30) have resented it and have so indicated. What is most irksome is that Grierson would group Maithili and Bhojpuri together as dialects of a common Bihari while he himself was so well aware of the two separate cultural and linguistic as well as literary traditions, and even said that Bojpuri "belongs rather to the United Provinces than to Bihár,...and all its associations and traditions point to the west and not to the east" (*Linguistic Survey of India* 5:2, 40). A similar viewpoint was expressed by Chatterji (1926:99):

> The Bhōjpuriyā [i.e., Bhojpuri] territory has always been under the influence of the West, and Western forms of speech,

like Braj-bhākā and Awadhi, and literary Hindūstānī (Hindī and Urdū) in later times, have been cultivated by poets and others who spoke Bhōjpuriyā at home.

Mishra (1969b:270) sums up the popular sentiment of a modern Maithili writer in most forceful terms:

> There never was in the past nor exists today a language called Bihari. There is no mention of it in any literature, any document or any record. There is not a single individual who speaks or writes in the Bihari language as defined by Grierson. It has no script, no literature, no actual existence. It is purely a creation of Grierson's mind and lives in the philological works of the scholars who thoughtlessly copy Grierson's classification.

1.4. THE EARLIEST WRITTEN TEXT OF MAITHILI

The *Varṇa-Ratnâkara* of Jyotirīśvara-Kaviśekharâcārya (Chatterji and Misra, eds. 1940) is the oldest written text of the Maithili language. It dates back to the early 14th century and is preserved in a Ms. written in 1507. It is a prose text written in the Mithilāksár[5] script, which is closer to the Bengali writing system. The text is:

> a sort of lexicon of vernaculars and Sanskrit terms, a repository of literary similes and conventions dealing with the various things in the world and ideas which are usually treated in poetry. We have in it either bare lists of terms, or the similes and conventions are set in the framework of a number of descriptions.
>
> – (Chatterji and Misra, eds., 1940, – 'Introduction' xxi)

Some Maithili scholars (Mishra 1949:101–118; S.Jha 1958:32–36) claim vigorously that the *Caryāpadas* (Circa 800–1100) are also written in some form of Old Maithili, while the eminent Bengali scholar Chatterji (1926) argues that the *Caryāpadas* were written in Old Bengali. The argument continues, and the controversy rages on to include other Indian languages as well, as Chatterji (1949) observes:

> The fact the *Caryapadas* have been claimed for Old Assamese, Old Oriya, Old Maithili (and old Magahi) as much as for Old Bengali, only demonstrates the close kinship of these languages to one another; they have even been claimed for "old Hindi" taking "Hindi" in a loose and popular sense. Dr.Jayakant Misra [Mishra], like Dr.Subhadra Jha, thinks the *Caryas* are in Old Maithili. I still stick to my view, put forward in my *Origin and Development of the Bengali Language* (1926), that the *Caryas* were composed in

Old Bengali -- of course at a time when the divergences between Maithili and Bengali and Oriya and Assamese were not very prominent.

- ('Introduction' to Mishra 1949:x).

1.5. GENETIC CLASSIFICATION

No two linguists agree on how exactly to classify the Indo-Aryan languages, showing the place of Maithili among them. Prominent among those who have treated the problem are: Grierson (1883a; 1918; 1919), Chatterji (1926), Mishra (1949), S.Jha (1958), G.Jha (1974) and Jeffers (1976).

The earliest classification of the NIA languages is that provided by Grierson (1883a), who described Maithili as a dialect of Bihari -- a descendant of the Mágadhí-derived Gaudian language, but quite distinct from the Hindi language (see Figure 1.1).

Later, Grierson (1918; 1919; 1927) stipulated what is now known as the "inner group - outer group"[6] theory of Aryan migration into India, and provided a slightly different grouping of the Indo-Aryan languages. He divided them into three main divisions, the grouping of which was "based on linguistic considerations and also coincides with the geographical distribution of various languages" (Grierson 1918:49), see Figures 1.2 and 1.3.

Chatterji (1926), like Grierson (1883a) believes that Maithili belongs to the group of Māgadhī Apabhraṁśa (called Mágadhí Prákrit by Grierson). He was also the first linguist to distinguish Maithili and Bhōjpuriyā [Bhojpuri] as belonging to two separate branches of the Magadhan subfamily (see Figure 1.4). Chatterji (1926) observes:

> Bhōjpuriyā somewhat stands apart from its sister-speeches, having come under the influence of its western neighbour Awadhī (Ardha-Magadhī) from very early times. ...But the sharp distinction between Bhōjpuriyā and Maithilī-Magadhī in their conjugation would justify their relegation to two separate groups, at least for the modern age.
>
> - ('Introduction', p.92).

Most native Maithili scholars seem to go along with Chatterji's (1926) classification, with some minor modifications. Such a classification enables them to emphasize two main points, i.e., that Maithili is not a dialect of Hindi, and that Maithili is not a dialect of Bihari and hence ought not to be grouped with Bhojpuri.

S.Jha's (1958) classification, which is often quoted in the Maithili language texts, is shown in Figure 1.5.

More recently, in a study based on the strict principles of historical and comparative linguistics, Jeffers (1976) has attempted to establish the position of the 'Bihari' languages (i.e., Maithili, Magahi and Bhojpuri) within the Indo-Aryan Family. He concludes that:

> ...on the basis of the criterion of shared phonological innovation, Bihārī cannot be considered a branch of the Eastern group of Indo-Aryan languages which includes Bengali, Assamese, and Oriyā, as has traditionally been assumed. The only plonological innovations which Bihārī shows with languages in its geographic vicinity must be assumed to present reflexes of phonological changes which affect a large MIA [Middle Indo Aryan] dialect region which incorporated, at least, East and West Hindī, Bihārī, and the Eastern languages. - (p.224)

To sum up, it seems fair to conclude that it is quite possible that the genetic classification problems that have arisen stem from the fact that there exists a dialect chain, or continuum, and therefore, it is difficult, or at least arbitrary, to treat the genetic classification of Maithili within the Stammbaum model.

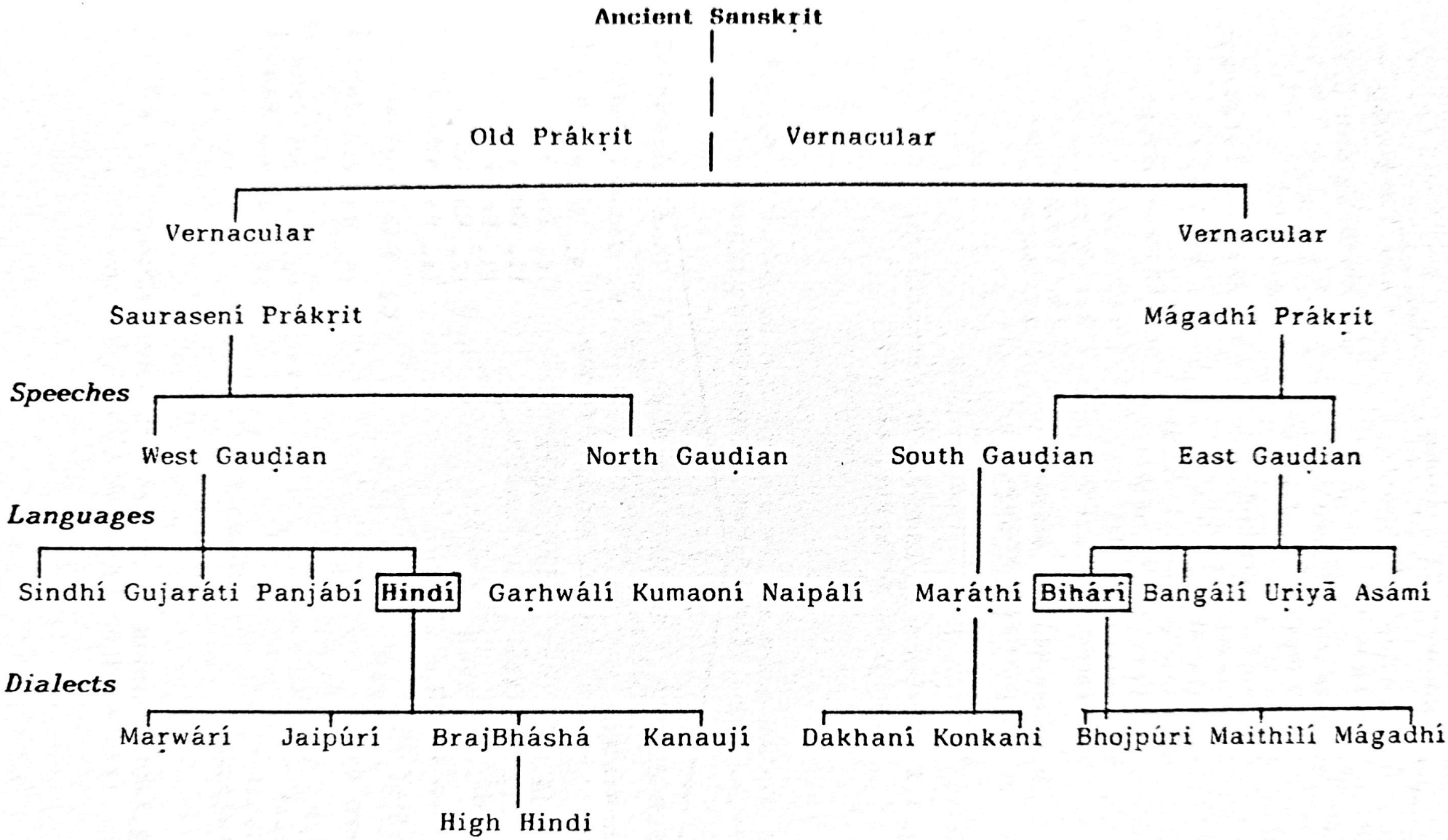

Fig.1.1 Genetic Classifications of NIA Languages, according to Grierson (1883a)

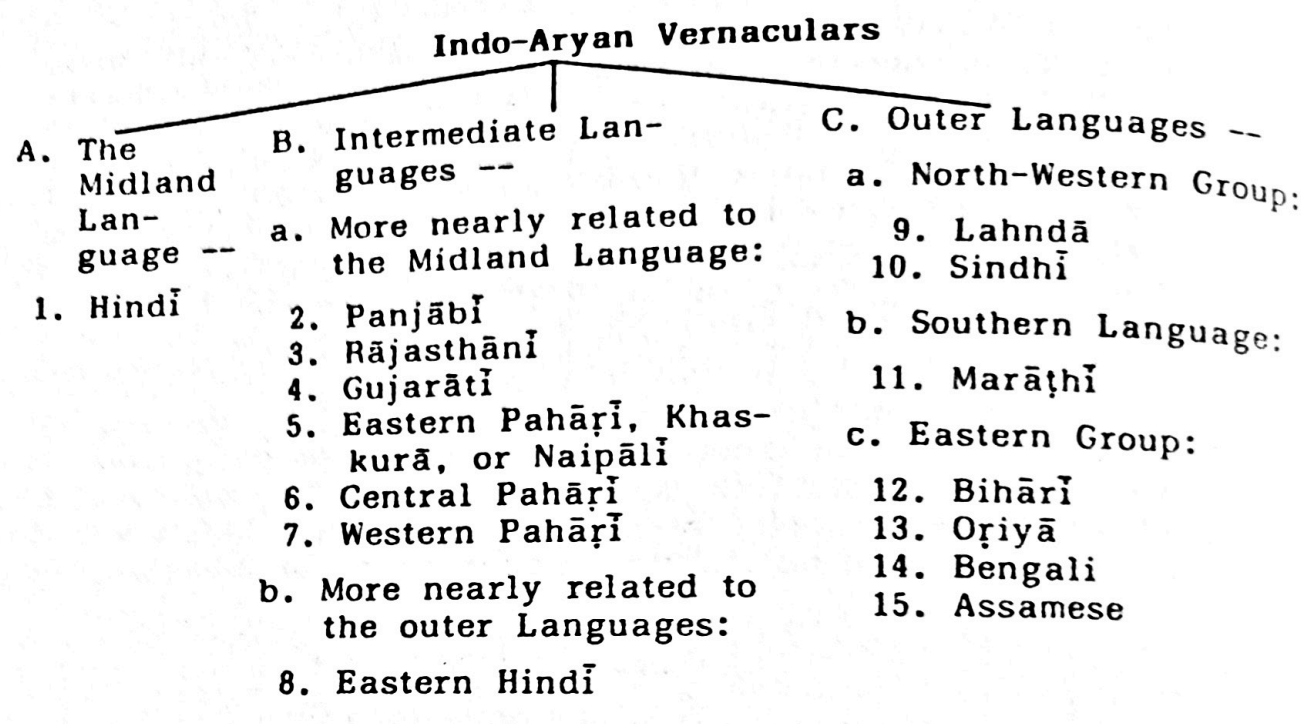

Fig.1.2 Division of Indo-Aryan Vernaculars, based on Grierson (1918:49).

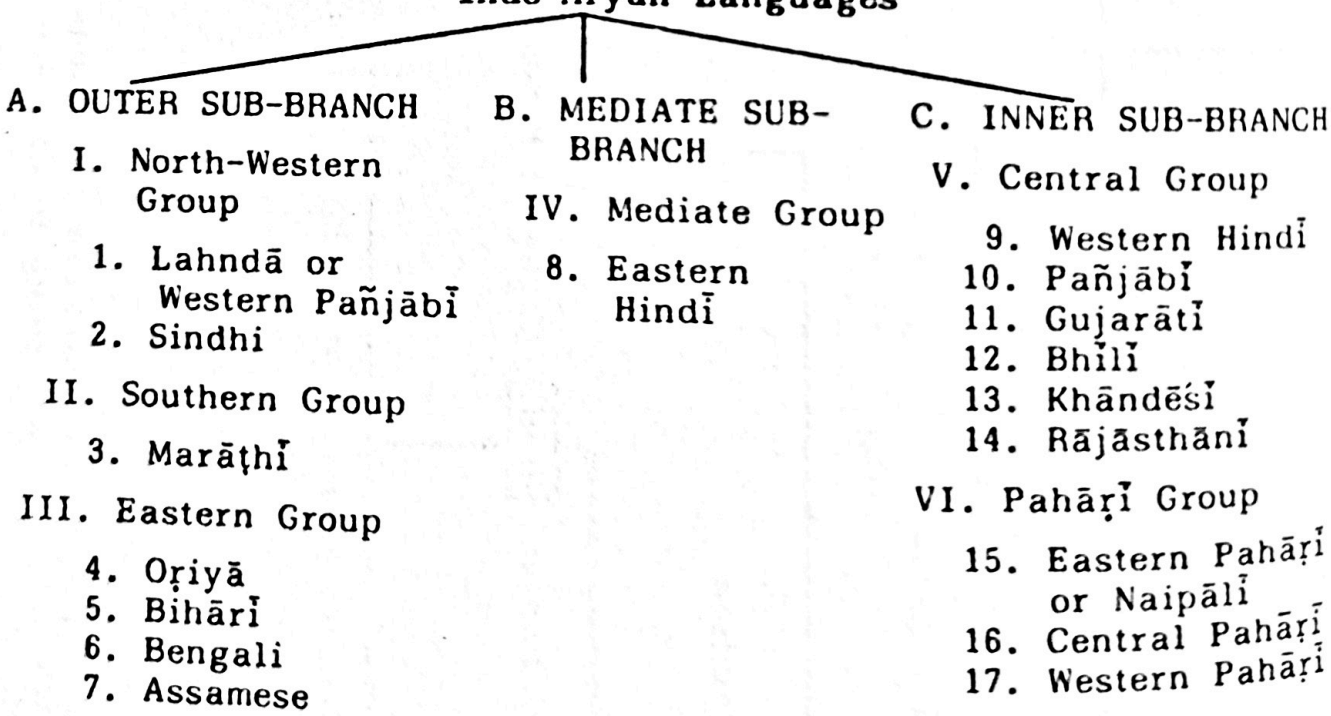

Fig.1.3 Division of Indo-Aryan Languages, based on Grierson (1927:120).

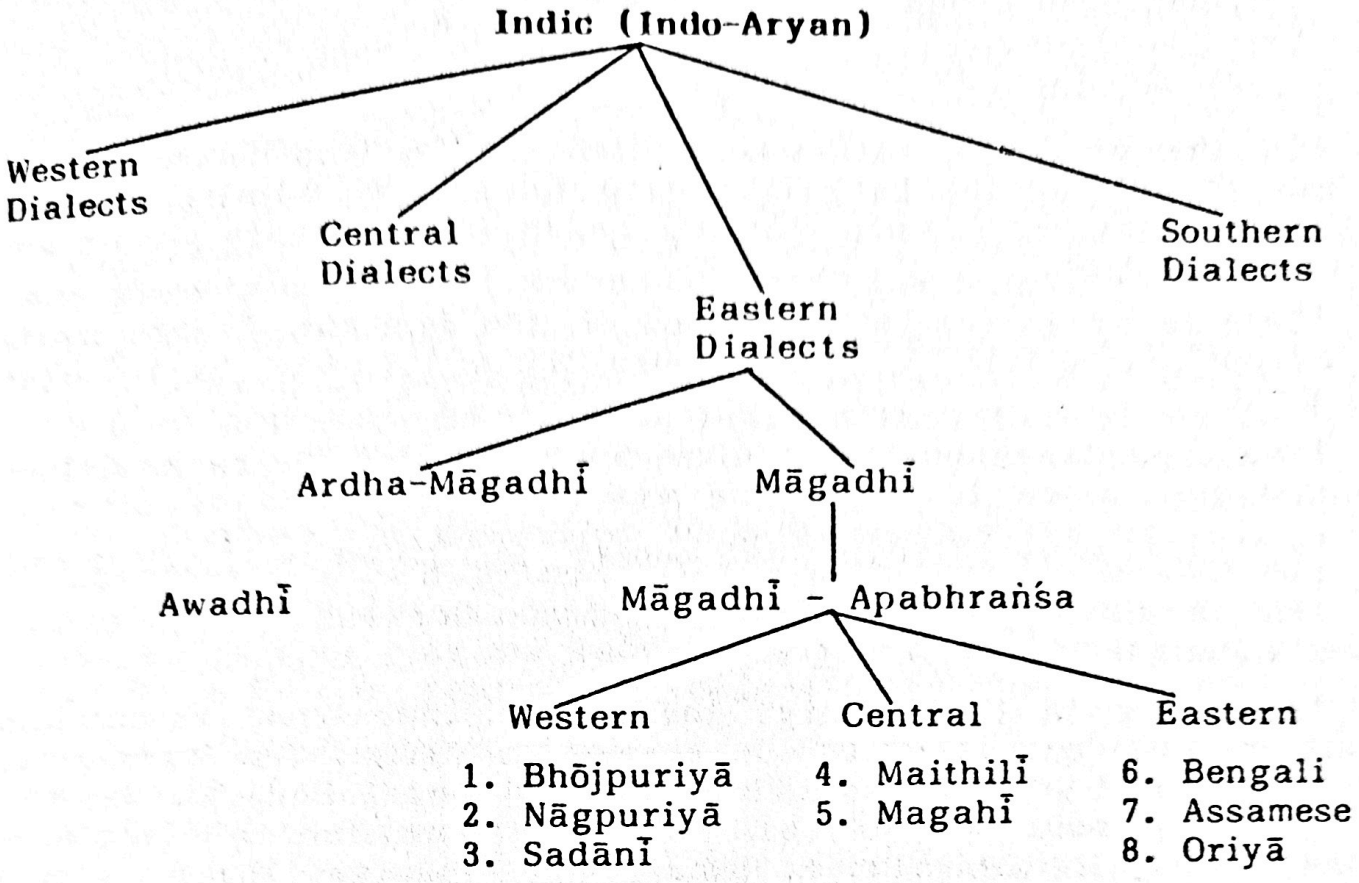

Fig.1.4 Division of NIA Languages, Showing Mainly the Languages of North India; based on Chatterji (1926)

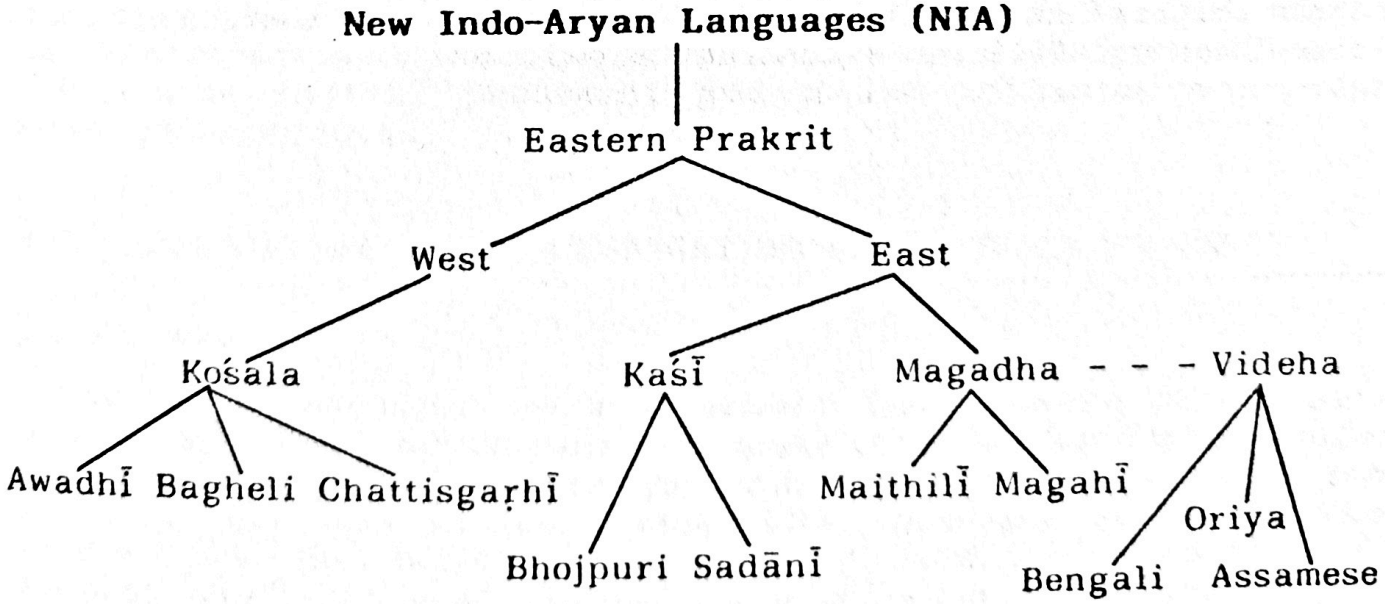

Fig.1.5 Genetic Relation of Maithili to other NIA Languages of Eastern India, based on S.Jha (1958)

Notes

[1] In the past, Maithili was written in the Mithilākśar script, which is akin to the Bengali writing system. No definite date can be determined as to when Maithili began to be written in the Devanagari script.

[2] This is an extrapolation, based on the fact that Beames treats Vidyapati (1360-1448) -- the greatest Maithili poet -- as a Bengali poet.

[3] The first language is Nepali -- which is also the national language.

[4] H.T.Colebrooke (1801), as quoted in J.Mishra (1949:39-40).

[5] For a history of the origin and development of this script, see R.Jha (1971).

[6] According to this theory, the modern Indo-Aryan vernaculars fall into two groups -- the Inner and the Outer. The Inner group is constituted of languages like Western Hindi, Panjabi, Gujarati and Rajasthani, while the Outer group consists of languages like Sindhi, Marathi, Oriya, Bihari and Assamese. The two groups of languages exhibit fundamental phonetic, phonological and morphological differences. These differences are ascribed to separate invasions of groups of Aryans into India. It is argued that the Outer group of Aryans came to India first and settled in the Madhyadeśa i.e., Eastern Panjab and Western U.P. The Inner group of Aryans invaded later and pushed the Outer group out of their original homes, forcing them to move north, east, and south. (See Chatterji 1926 for a contrary view).

2 SEGMENTAL PHONOLOGY

2.1. PREVIOUS STUDIES

The earliest study of Maithili phonetics and phonology is that of Grierson (1881:5-8) in which he simply mentions the alphabet and gives some rules of pronunciation of the following types:

> The pronunciation of the vowel *a* [transcribed as [ə] in this study] is peculiar. It is not so broad as in Bengálí, but on the other hand, it is broader than that of the neutral vowel in High Hindí. I know of no sound exactly equivalent to it in any language with which I am acquainted. The best way of describing it is by saying that it is half way between the o in *not* and the *u* in *nut*, when preceded by a hard guttural check, and followed by a soft labial check. It thus may be said to be the *u* in *cub* , rounded, or the o in *cob*, neutralized. (pages 5-6)

S.Jha's (1949) paper is probably the first synchronic study of the phonetics and phonology of Maithili according to the principles of modern descriptive linguistics. In that study, Jha argues for fifty-six "essential" (p.435) phonemes of Maithili: to him every grapheme is a phoneme. Later, (1958) he discusses the historical development of the Maithili sound system and provides diachronic explanations for the synchronic usage. Recently G.Jha (1974: 56-119) has also attempted to describe the phonology of Maithili, but his description, like that of S.Jha, is highly traditional and characterized by over-differentiation.

This chapter will present a short description of Maithili vowels and consonants and their phonemic analysis, a distinctive feature analysis of Maithili phonemes, and a list of tentative segment structure conditions.

2.2. DESCRIPTION AND CLASSIFICATION OF MAITHILI SOUNDS

2.2.1. Vowels

Vowels are produced by a relatively free passage of the airstream. The vocal cords are in a state of vibration. Articulatorily vowels may be described in terms of four factors: (i) the height of the body of the tongue, (ii) front-back position of the tongue, (iii) the degree of lip rounding, and (iv) velic closure. Maithili has eight oral vowels: [i e æ ə a ɔ o u]. All these vowels may also be nasalized. The acoustic characteristics of these vowels will be discussed in Chapter 4.

Front Vowels

[i]

The Maithili [i] is produced by raising the front of the tongue towards the hard palate. The lips are unrounded and the soft palate is in a raised position. [i] may be described as a high front unrounded oral vowel.

[e]

The Maithili [e] is produced by raising the front of the tongue half-way towards the hard palate. The lips are unrounded and the soft palate is in a raised position. [e] may be described as a mid front unrounded oral vowel.

[æ]

The Maithili [æ] is produced by raising only slightly the front of the tongue towards the hard palate. The lips are spread and the soft palate is in a raised position. [æ] may be described as a low front unrounded oral vowel.

Central Vowels

[ə]

The Maithili [ə] is produced by raising the mid part of the tongue slightly towards the central part of the roof of the mouth. The lips are unrounded and the soft palate is in a raised position. [ə] may be described as a mid central unrounded oral vowel.

[a]

In the formation of the Maithili [a], the tongue is quite low down in the mouth and the highest point of the tongue is in the center of the roof of the mouth. The lips are unrounded and the soft palate is in a raised position. [a] may be described as a low central unrounded oral vowel.

Back Vowels

[u]

The Maithili [u] is produced by raising the back of the tongue towards the soft palate. The lips are rounded and the soft palate is in a raised position. [u] may be described as a high back rounded oral vowel.

[o]

The Maithili [o] is produced by raising the mid part of the back of the tongue towards the soft palate. The lips are rounded and the soft palate is in a raised position. [o] may be described as a mid back rounded oral vowel.

[ɔ]

The Maithili [ɔ] is produced by the lower part of the back of the tongue raised towards the soft palate. The lips are rounded and the soft palate is in a raised position. [ɔ] may be described as a low back rounded oral vowel.

Nasalized Vowels

[ĩ ẽ æ̃ ə̃ ã õ ɔ̃ ũ]

The nasalized vowels of Maithili are produced exactly like their oral counterparts except that during their production the soft palate is in a lowered position so that air also passes through the nose.

2.2.2. Consonants

Consonants are produced by bringing the two articulators very close together and thereby obstructing the airstream at some point in the vocal tract. It is customary to describe and classify consonants in terms of: (i) place of articulation, (ii) manner of articulation (i.e., the type of obstruction which the articulators make for the production of the segment), (iii) state of vocal cords, and (iv) velic closure (oral or nasal). A phonetic feature of gemination also characterizes the consonant system of Maithili (see 2.3.3.). Below is given a short description of the consonants of Maithili in terms of place and manner of articulations:

2.2.2.1. Places of Articulation

Bilabial: Produced by bringing the two lips together:
[p p^h b b^h; m m^h; w].

Dental: Produced by the tip or blade of the tongue against the upper front teeth: [t t^h d d^h; s; n n^h; r r^h; l l^h].

Retroflex: Produced by the tip of the tongue curled back against the back of the alveolar ridge:
[ṭ $ṭ^h$ ḍ $ḍ^h$; ṣ, ṇ, ṛ].

Palatal: Produced by the front of the tongue against the hard palate:
[č $č^h$ ǰ $ǰ^h$; š, y].

Velar: Produced by the back of the tongue against the soft palate:
[k k^h g g^h; ŋ $ŋ^h$].

Glottal: Produced in the glottis with no articulators being used:
[h].

2.2.2.2. Manners of Articulation

Stop:

A stop is a type of consonant sound produced by a complete closure of the articulators involved so that the airstream is momentarily compressed within the vocal tract. When the articulators come apart the air is released with a small burst or explosion. There are 20 stop consonant sounds in Maithili. These are of four glottal state types:

voiceless unaspirated	[p t ṭ k]
voiceless aspirated	[p^h t^h $ṭ^h$ k^h]
voiced unaspirated	[b d ḍ g]
voiced aspirated	[b^h d^h $ḍ^h$ g^h]

Affricate:

An affricate is a type of stop consonant sound in which the articulators come togehter for the stop closure, and then, they separate slowly and slightly so that a fricative is made at the same place of articulation. Like stops, there are four types of affricates in Maithili:

voiceless unaspirated	[č]
voiceless aspirated	[$č^h$]
voiced unaspirated	[ǰ]
voiced aspirated	[$ǰ^h$]

Nasal:

A nasal consonant is produced by completely stopping the airstream in the oral cavity and by lowering the soft palate so that the air escapes through the nose. There are two types of nasal sounds in Maithili -- aspirated and unaspirated:

[m m^h; n n^h; ṇ; ŋ $ŋ^h$].

Fricative:

For most fricative consonants the two articulators come close so that the airstream is partially obstructed and when it is released it produces a turbulence or an audible friction. For /h/, however, the turbulence is in the entire vocal tract. Maithili has four fricative sounds:

[s, ṣ, š, h].

Tap:

A tap consonant is produced by an obstruction which the tongue makes in a single tap against the alveolar-ridge. There are two manner types of taps in Maithili - aspirated and unaspirated. Examples:

[r, r^h].

Lateral:

A lateral consonant is produced by raising the tip of the tongue against the alveolar-ridge in such a way that there is a complete obstruction of the airstream in the center of the oral tract and yet the air is allowed to escape over or both sides of the tongue. There are two types of lateral sounds in Maithili -- aspirated and unaspirated: [l, l^h].

Approximant:

An approximant is a sound produced by bringing one articulator towards another without producing a turbulent airstream. There are two approximants in Maithili: [w, y].

2.3. PHONEMIC ANALYSIS

In traditional segmental notation, Maithili has the set of phonological units presented in Table 2.I.

As shown in Table 2.I there are 26 consonant phonemes and 8 oral vowel phonemes in Maithili. All vowels can be nasalized underlyingly -- thus increasing the number of vowel phonemes to 16. All underlying segments also surface as phonetic segments. Marginal phonemes, whose status is questionable, are indicated by parenthesis -- their exact nature will be discussed in 2.3.4.

2.3.1. Vowels

The eight oral vowel phonemes in Maithili are: /i/ high front, /e/ mid front, /æ/ low front, /ə/ mid central, /a/ low central, /u/ high back, /o/ mid back, and /ɔ/ low back. Only the back vowels are rounded. Length is not distinctive in Maithili -- although the Devanagari script in which Maithili is now written does provide separate graphemes for long and short vowel phonemes.

2.3.1.1. Front Vowels

The phonological opposition between the front vowels /i e æ/ is shown below:

Initial		*Medial*		*Final*	
/i/	'this'	/pir/	'pain'	/ki/	'what'
/ek/	'one'	/per/	'tree'	/ke/	'who'
/æb/	'defect'	/pær/	'leg'	/gæ/	'cow'
/'isər/	'God'	/t^hik/	'true'		
/'ekər/	'his'	/gen/	'ball'		
/æs/	'luxury'	/gæn/	'knowledge'		

Of the front vowels, /æ/ is the least frequent. Furthermore, in some dialects, /æ/ is diphthongized as [aĕ] or [əĕ] or [aĭ], e.g.

/æs/	[əĕs]	'luxury'
/æb/	[əĕb]	'defect'
/pær/	[pəĕr]	'leg'
/gæ/	[gaĭ]	'cow'
/b^hæ/	[b^haĭ]	'brother'
/mæ/	[maĕ]	'mother'

Tentatively, a low level phonetic rule, given below, may describe the above sociolinguistic variation:

$$/æ/ \longrightarrow \left\{ \begin{array}{ll} [əĕ]/ & -- \ C \\ [aĭ]/ & C \ -- \ Nasal \\ [aĕ] & \text{elsewhere} \end{array} \right\} \Big/ \left[\begin{array}{l} \text{non-brahmin style } \textit{or} \\ \text{less elegant style } \textit{or} \\ \text{uneducated style} \end{array} \right]$$

2.3.1.2. Central Vowels

The phonological contrast between the central vowels /ə a/ is exemplified below:

Initial

/ən/	'grain'
/an/	'bring'
/ər/	'stick to (something)'
/as/	'hope'
/'əskər/	'alone'
/'as#kər/	'do the hoping'

Final

/'kər/	'do (imp.)'
/'kəra/	'hard'
/'pərə/	'fall (imp.)'
/'pəra/	'he buffalo'
/'p^hərə/	'bear fruit (imp.)'
/'p^həra/	'slice'

Medial

/kəl/	'machine'
/kal/	'time'
/p^hər/	'fruit; seed'
/p^har/	'plowshare'
/'čələ/	'let's go'
/'čalə/	'(you) make a move'
/kə'hər/	'groan (imp.)'
/kə'har/	'carrier'
/pə'g^hər/	'melt (intransitive)'
/pə'g^har/	'melt (causative)'

/ə/ occurs primarily in non-final positions. In the final position it appears mainly in the imperative construction. It is worth noting here that the traditional descriptions of Maithili

Consonants

	bilabial	*dental*	*retroflex*	*palatal*	*velar*	*glottal*
Stops	p	t	ʈ		k	
	p^h	t^h	$ʈ^h$		k^h	
	b	d	ɖ		g	
	b^h	d^h	$ɖ^h$		g^h	
Affricates				č		
				$č^h$		
				ǰ		
				$ǰ^h$		
Fricatives		s	(ʂ)	(š)		h
Nasals	m	n	(ɳ)		(ŋ)	
Tap		r	(ɽ)			
Lateral		l				
Approximants	(w)			(y)		

Vowels

i		u		
e	ə	o	± ~	(nasalization)
æ	a	ɔ		

Diphthongs

(əi) (əu)

Table 2.I: Inventory of Maithili Phonemes

(and of other modern Indo-Aryan languages) transcribe all final consonants as if they were followed by a schwa /ə/, e.g., /kal/ is written /kalə/. There is no empirical reason for continuing to do so, since these "inherent vowels" were dropped centuries ago.

2.3.1.3. Back Vowels

The back vowels /u o ɔ/ are rounded and show phonological opposition in all positions, e.g.

Initial		*Medial*	
/us/	'whitener'	/kus/	'a kind of grass used for worship'
/os/	'frost'	/kos/	'two miles'
/or^h/	'cover' (imp.)	/lor/	'tears'

/ɔr^{h}/	'out of sight'	/lɔr/	'male organ'
/'otə/	'there'	/b^{h}uǰ/	'fry'
/'ɔta/	'will come'	/b^{h}oǰ/	'feast'
		/p^{h}ɔǰ/	'army'

Final

/'suru/	'beginning'
/'načǔ/	'dance (imp.)'
/'kəru/	'do (imp.)'
/'koro/	'bamboo poles used in a thatched house'
/'oho/	'he too'
/'səro/	'wrestling'
/ho/	'be/become'
/hɔ/	'whoa!'

Of the back vowels, /ɔ/ is the least common -- especially in the final position. Also, in some dialects /ɔ/ varies freely with [o] and [əŭ], e.g.

['səro]	~	['səro]	'wrestling'
['ɔta]	~	['əŭta]	'will come'
[kɔr]	~	[kor]	'morsel'

2.3.1.4. High Vowels

The high vowels /i u/ contrast in all positions, e.g.

Initial

/'isər/	'God'
/'usər/	'fallow'
/i'nar/	'well'
/u'nar/	'unbalanced'
/'isa/	'Jesus'
/'usa/	'proper name'

Medial

/mit/	'friend'
/mut/	'urine'
/kiṭ/	'fix'
/kuṭ/	'beat'
/bə'hir/	'deaf'
/'bəhut/	'a lot'

Final

/'kəri/	'do (prohibitive)'
/'kəru/	'do (imp.)'; 'hot'
/'sari/	'sari'
/'sar^{h}u/	'wife's sister's husband'
/'tari/	'palm juice'
/'taru/	'fry (imp.)'
/'pisi/	'father's sister'
/'pisu/	'grind (imp.)'

2.3.1.5. Mid Vowels

The mid vowels /e ə o/ show phonological contrast in all positions. Examples are given below:

Initial		*Medial*		*Final*	
/'ena/	'like this'	/k^{h}et/	'field'	/he/	'a form of address'
/'ona/	'like that'	/k^{h}ət/	'mark'	/hə/	'oh!'
/'ənа/	'a coin'	/k^{h}od/	'dig'	/ho/	'be/become'
		/per/	'tree'		
		/pər/	'on'		
		/por/	'joint'		

2.3.1.6. Low Vowels

The low vowels /æ a ɔ/ show phonological contrasts as exemplified below:

Initial		*Medial*		*Final*	
/æs/	'luxury'	/pær/	'leg'	/sæ/	'thus'
/as/	'hope'	/par/	'across'	/sa/	'musical note'
/ɔr^{h}/	'out of sight'	/pɔr/	'last year'	/sɔ/	'hundred'
		/'pædəl/	'on foot'	/b^{h}æ/	'brother'
		/'padəl/	'farted'	/ba/	'open, e.g. mouth (imp.)'
		/'hata/	'tract of field'	/b^{h}ɔ/	'pretension'
		/'hɔda/	'elephant seat'		

2.3.1.7. Diphthongs

Most traditional accounts of Maithili phonology posit /əi/ and /əu/ as underlying diphthongs. Such a practice is heavily influenced by the orthography, which does provide separate letters for these sounds. However, since a sequence of vowels always causes diphthongization in Maithili, no diphthongs will be posited at the systematic phonemic level in this study (see page 45).

2.3.1.8. Nasalized Vowels

Vowel nasality is distinctive in Maithili. The contrast between the oral and nasalized vowels is shown below:

Initial

/is/	'expression of pain'	/uṭ^{h}/	'arise'
/ĩṭ/	'brick'	/ũṭ/	'camel'
/ek/	'one'	/o/	'he'
/ẽr/	'heel'	/õ/	'groaning sound'
/æb/	'defect'	/'ɔta$^{(h)}$/	'will come'
/ãæ/	'what!'	/'ɔ̃ṭəl/	'boiled'
/ə/	'the letter a'	/as/	'hope'
/ə̃/	'yes!'	/ãṭ/	'courage'

Medial

/č^{h}iṭ/	'scatter'	/sər/	'sir'
/č^{h}ĩṭ/	'a kind of dyed garment'	/sə̃r/	'rot'
/k^{h}et/	'field'	/bas/	'living'
/kẽt/	'cane'	/bãs/	'bamboo'
/g^{h}or/	'a yogurt drink'	/hə̃s/	'laugh'
/g^{h}õṭ/	'swallow'	/hãs/	'goose'
/'ḍora/	'thread'	/sur/	'tone'
/'ḍõra/	'deep ground' (low level)	/sũr^{h}/	'trunk'
/lɔt/	'skewed'	/'čura/	'flat rice'
/gɔ̃t/	'(cattle) urine'	/'sũra/	'grain bug'

Final

/'kəhi/	'(you) say' (non-honorific + imp.)	/kə'ra/	'cause it to be done'
/'kəhĩ/	'What if'	/kə'hã/	'where'
/'kəhu/	'(you) say' (honorific + imp.)	/hə/	'oh'
/'kəhũ/	'somewhere'	/hə̃/	'yes'
/sæ/	'thus'		
/sæ̃/	'husband'		
[sɔ]	'hundred'		
[sɔ̃]	'from'		

[ǰo]	'go (imp.)'	[k^ho]	'eat (imp.)'
[põ]	'sound of a clarinet'	[$'k^hõ'k^hõ$]	'cough'

Also, all vowels are phonetically nasalized when contiguous to a nasal consonant, e.g.

/mat/	[mãt]	'drunk'	/kam/	[kãm]	'job'
/mit/	[mĩt]	'friend'	/g^hum/	[g^hũm]	'turn'
/mut/	[mũt]	'urine'	/sim/	[sĩm]	'green beans'
/meṭ/	[mẽṭ]	'erase'	/gen/	[gẽn]	'ball'
/mɔt/	[mɔ̃t]	'death'	/gan/	[gãn]	'song'
/nek/	[nẽk]	'good conduct'	/gæn/	[gæ̃n]	'knowledge'
/nuk/	[nũk]	'hide'	/gɔn/	[gɔ̃n]	'secondary'
/nok/	[nõk]	'edge'	/gən/	[gə̃n]	'count'
/nak/	[nãk]	'nose'	/gun/	[gũn]	'quality'
/nik/	[nĩk]	'alright'	/p^hen/	[p^hẽn]	'lather'

2.3.2. Consonants

Maithili stops, like those of most Indo-Aryan languages, show a four-way contrast between voiced and voiceless and aspirated and unaspirated at bilabial, dental, retroflex, palatal, and velar places of articulation. Phonologically, affricates also behave like stops. Phonetically the taps, laterals and nasals also show a two-way contrast between aspirated and unaspirated. Aspiration, thus, is an overriding characteristic of the Maithili sound system (see Chapter 3 for a detailed discussion).

2.3.2.1. Stops

Bilabials

The bilabial stops /p p^h b b^h/ show the contrast between voiced and voiceless and aspirated and unaspirated in all positions, e.g.

Initial		*Medial*		*Final*	
/pul/	'bridge'	/'nəpa/	'measure'	/sãp/	'snake'
/p^hul/	'flower'	/'nəp^{h}a/	'profit'	/sap^h/	'clean'
/bul/	'walk'	/'ləbhi / 'labhi/	'bring'	/k^{h}ep/	'times'
/b^hul/	'forget'			/k^{h}eb/	'sail'
		/'lab^{h}i/	'umbilical cord'	/k^{h}eb^h/	'plant seeds'

Dentals

The dental stops /t t^h d d^h/ too show phonological opposition in all positions. Examples:

Initial		*Medial*		*Final*	
/tan/	'music'	/'poti/	'grand-daughter'	/bat/	'talk; matter'
/t^han/	'several yards of cloth'	/'pot^{h}i/	'book'	/bat^h/	'pain'
/dan/	'charity'	/u'dar/	'generous'	/bad/	'after'
/d^han/	'paddy'	/u'd^har/	'credit'	/bad^h/	'out into the fields'

Retroflex

The retroflex stops /ṭ $ṭ^h$/ show full contrast in all positions, while /ḍ $ḍ^h$/ show phonological opposition only in non-final positions. /ḍ/ never occurs intervocalically. Examples:

Initial		*Medial*		*Final*	
/ṭik/	'pigtail'	/'kəṭgər/	'shapely'	/kaṭ/	'cut'
/$ṭ^h$ik/	'true'	/'kə$ṭ^h$gər/	'solid'	/kaṭ^h/	'wood'
/ḍik/	'huge mound'	/'ənḍa/	'egg'	/ṭaṭ/	'light fence'
/ḍol/	'small bucket'	/'$ṭ^h$ən$ḍ^h$a/	'cool; cold'	/$ṭ^h$a$ṭ^h$/	'pomp'
/$ḍ^h$ol/	'drum'			/ḍãṭ/	'scold'
				/$ḍ^h$a$ṭ^h$/	'heavy fence'

/ḍ/ is a defective phoneme, occurring word-finally only if preceded by a nasal consonant, which is assimilated to the retroflex place of articulation of /ḍ/ (see section 2.3.4.). Examples of /ḍ/ in final position:

/ḍəṇḍ/	[ḍəṇḍ]	'punishment'
/k^həṇḍ/	[k^həṇḍ]	'piece'
/kaṇḍ/	[kaṇḍ]	'canto'

Word-finally and postvocalically /$ḍ^h$/ surfaces as [r^h] or [rh] (see section 2.3.5.), e.g.

/sãḍ^{h}/	[sãr^{h}]	'bull'
/pəḍ^{h}/	[pər^{h}]	'read'
/piḍ^{h}i/	['pir^{h}i] ~ ['pirhi]	'low stool'
/bəḍ^{h}əl/	['bər^{h}əl] ~ ['bərhəl]	'grown'
/bəḍ^{h}təi/	['bər^{h}təĭ]	'will grow'

Palatals

The affricates /č č^{h} ǰ ǰ^{h}/, like stops, show full phonological contrast in all positions. Examples:

Initial		*Medial*		*Final*	
/čor/	'thief'	/ə̃'čar/	'pickle'	/bič/	'center'
/č^{h}or/	'edge'	/ə'č^{h}ar/	'shower'	/bič^{h}/	'pick up'
/ǰor/	'strength'	/'baǰəl/	'spoke(n)'	/biǰ/	'seed'
/ǰ^{h}or/	'soup'	/'baǰ^{h}əl/	'entangled'	/biǰ^{h}/	'rust'

Velars

The velars /k k^{h} g g^{h}/ also show full contrast in all positions, e.g.

Initial		*Medial*		*Final*	
/kam/	'job'	/'kəkri/	'a fruit'	/bik/	'sell'
/k^{h}am/	'pole'	/'k^{h}ək^{h}ri/	'paddy without rice'	/bik^{h}/	'poison'
/gam/	'village'	/'gəgri/	'small pitcher'	/bak/	'speech'
/g^{h}am/	'sunrays; sweat'	/'g^{h}əg^{h}ri/	'skirt'	/bag/	'garden'
				/bag^{h}/	'tiger'

2.3.2.2. Liquids

The liquids, i.e., tap and lateral, /r l/, like the stops, show full phonological opposition in all positions, e.g.

Initial		*Medial*		*Final*	
/rer/	'crowd'	/'piri/	'elevated mass of clay -- used for worship	/čir/	'a kind of garment'
/ler/	'saliva'	/'pili/	'(I) drank'	/čil/	'eagle'
/ret/	'sand'	/'baru/	'light (imp.)'	/bər/	'bridegroom'
/let/	'will take'	/'balu/	'sand'	/bəl/	'strength'

				/lar/	'straw'
/rog/	'disease'	/čə'ra/	'cause to graze (imp.)'		
				/lal/	'read'
/log/	'people'	/čə'la/	'cause to move (imp.)'		

2.3.2.3. Nasals

The phonological opposition between the nasals /m n/ is exemplified by the examples given below.

Initial		*Medial*		*Final*	
/mam/	'mother's brother'	/'sami/	'husband'	/kam/	'job'
/nam/	'name'	/'sani/	'cattle fodder'	/kan/	'ear'
/mem/	'madam'	/kə'ma/	'earn (imp.)'	/sim/	'green beans'
/nem/	'conduct'	/kə'na/	'cause to weep (imp.)'	/sin/	'frost'
		/'mami/	'mother's brother's wife'	/tam/	'copper'
		/'nani/	'mother's mother'	/tan/	'music; pull'

2.3.2.4. Fricatives

The fricatives /s h/ also show full phonological opposition in all positions, e.g.

Initial		*Medial*		*Final*	
/saṭ/	'paste (imp.)'	/pə'sar/	'spread (causative)'	/bas/	'habitation'
/haṭ/	'market'	/pə'har/	'mountain'	/bah/	'bah!'
/sat^{h}/	'with'	/'kəsu/	'tighten (imp.)'	/čas/	'a certain style of ploughing'
/hat^{h}/	'hand'	/'kəhu/	'say (imp.)'	/čah/	'tea'; 'desire'
/sar/	'wife's brother'	/pə'sin/	'liking'	/g^{h}as/	'grass'
/har/	'garland'	/pə'hin/	'wear'	/g^{h}ah/	'wound'
/sək/	'power'			/kəs/	'tighten (imp. + non-honorific)'
/hək/	'right'			/kəh/	'say (imp. + non-honorific)'
/sut/	'sleep'				
/hut^{h}/	'ridicule'			/rəs/	'juice'
				/rəh/	'stay'

2.3.3. Gemination

As mentioned earlier, gemination is one of the characteristics of the Maithili consonant system. It is, however, phonetically conditioned, occurring only intervocalically where the preceding vowel (usually but not always a schwa /ə/) is stressed. Such geminate consonants are in free variation with non-geminate consonants in similar environments. Examples are given below:

['pətta]	~	['pəta]	'leaf'
['pətt^{h}a]	~	['pət^{h}a]	'strong'
['bəčča]	~	['bəča]	'child'
['gədda]	~	['gəda]	'heavy staff'
['rəggər]	~	['rəgər]	'obstinacy'
['kətt^{h}a]	~	['kət^{h}a]	'a form of land measurement'
['kəmmər]	~	['kəmər]	'blanket'
['rəssa]	~	['rəsa]	'rope'
['bərre]	~	['bəre]	'pimple'
['həlla]	~	['həla]	'noise'
['dibba]	~	['diba]	'small can'
['ijjət]	~	['ijət]	'character; honor'
['kurra]	~	['kura]	'gargle'
['murr^{h}i]	~	['mur^{h}i]	'rice pops'

In the present study, these geminates have been arbitrarily treated as clusters rather than units. A low level phonetic rule of the type given below may account for the variation of geminate and non-geminate consonants in the intervocalic position:

$$C_i \longrightarrow C_i\ C_i \quad / \quad V \quad \underline{\qquad} \quad V$$
$$[+\ \text{Stress}]$$

This rule says that in Maithili a consonant is geminated intervocalically only if the preceding vowel is stressed. In those instances where the succeeding vowel is stressed, gemination never occurs, e.g.

[nə'pa]	'(imp.) cause to measure'
*[nə'ppa]	
[pə'ṭ^{h}a]	'(imp.) cause to arrive; deliver'
*[pə'tt^{h}a]	
[gi'ra]	'(imp.) cause to fall'
*[gi'rra]	

[hə'la] '(imp.) cause to deepen'
*[hə'lla]

The above, however, is only a tentative account. Further investigation needs to be undertaken.

2.3.4. Marginal Phonemes

/ŋ/	[ŋ]	velar nasal
/ṇ/	[ɳ]	retroflex nasal
/š̆/	[ʃ]	palato-alveolar frictative
/ṣ/	[ʂ]	retroflex frictative
/ṛ/	[ɽ]	retroflex flap
/w/	[w]	bilabial approximant
/y/	[j]	palatal approximant

Table 2.II: Marginal Phonemes of Maithili

Table 2.II lists a number of sounds which have been termed 'marginal' phonemes. Column 1 lists the transcription used in this study, column 2 provides the International Phonetic Association (IPA) symbol and column 3 gives the appropriate articulatory description. All these so-called 'marginal' phonemes are in fact phonemes of Sanskrit and it has been customary to treat them as phonemes of various modern Indo-Aryan languages, including Maithili. Such a pratice is further strengthened by the fact that the Devanagari script provides separate letters for all these sounds. There is, however, some justification for omitting these sounds from the inventory of Maithili phonemes.

The velar nasal [ŋ], as in most languages, occurs only non-initially and is followed by a homorganic stop, which if voiced and non-final may be deleted in some dialects. The voiced stop is always deleted in final position. Examples:

Medial

/j̆əngəl/	['j̆əŋgəl]	~	['j̆əŋəl]	'forest'
/j̆əngəl+i/	['j̆əŋgli]	~	['jəŋli]	'wild'
/ləngra/	['ləŋgra]	~	['ləŋra]	'lame'
/kəngna/	['kəŋgna]	~	['kəŋna]	'bangles'
/kəng^{h}i/	['kəŋg^{h}i]	~	['kəŋ^{h}i]	'comb'
/singar/	[siŋ'gar]	~	[si'ŋar]	'decoration'
/kəngal/	[kəŋ'gal]	~	[kə'ŋal]	'poor'
/lungi/	['luŋgi]	~	['luŋi]	'a dress'

/pəŋkʰa/	['pəŋkʰa]	'fan'
/ḍəŋka/	['ḍəŋka]	'huge drum'
/səŋka/	['səŋka]	'suspicion'

Final

/pəŋkʰ/	[pəŋkʰ]	'wings'
/əŋk/	[əŋk]	'number'
/aŋg/	[aŋ]	'body'
/ṭaŋg/	[ṭaŋ]	'leg'
/bʰaŋg/	[bʰaŋ]	'a marijuana--type plant'
/muŋg/	[muŋ]	'a lentil'

The retroflex nasal [ṇ] also occurs only before /ḍ/ (except in highly literary styles in borrowed words -- see below). Examples are given below:

Medial

/əṇḍa/	['əṇḍa]	'egg'
/ṭʰəṇḍʰa/	['ṭʰəṇḍʰa]	'cool; cold'
/ḍəṇḍa/	['ḍəṇḍa]	'heavy staff'
/ḍəṇḍ/	[ḍəṇḍ]	'punishment'
/kaṇḍ/	[kaṇḍ]	'canto'

The position taken in this study is that the velar nasal [ŋ] and the retroflex nasal [ṇ] should be derived from underlying /n/ -- before a velar stop and a retroflex stop, respectively. The surface forms in the above examples are derived after a regressive assimilation has occurred. A low level phonetic rule of g--deletion in word final position is applied after the assimilation rule has applied (see p.32). These processes are summarized below:

Assimilation Rule

$$[+\text{ nasal}] \longrightarrow [\alpha\text{ place}] / \begin{bmatrix} +\text{ cons} \\ \alpha\text{ place} \end{bmatrix}$$

g-deletion Rule

$$g \longrightarrow \emptyset \;/\; [+\text{ nasal}] \;____\; \#$$

In some dialects, the g-deletion rule applies in medial as well as word final position and can be written as

$$g \longrightarrow \emptyset \;/\; [+\text{ nasal}] \;____$$

Maithili has borrowed extensively from Sanskrit -- either directly, or indirectly through Hindi. Most educated speakers of Maithili

also tend to know Hindi and Sanskrit. All this has had a curious impact upon the phonology of Maithili. In literate and educated varieties of speech, for instance, the native speakers of Maithili tend to retain the original pronunciation of the borrowed words. In less literary styles, however, they abandon it. This is highly evident in the variation that occurs, for instance, between the final retroflex nasal [ṇ] and the dental nasal [n]:

[baṇ]	~	[ban]	'arrow'
[praṇ]	~	[pran]	'life'
[koṇ]	~	[kon]	'angle'

Similar stylistic variation also occurs in the cases of [š] and [ṣ] which are replaced by [s], and of [ṛ] which is replaced by a nonretroflex tap [r], and of [w] which is replaced by [b]. And [y] and [ǰ] vary freely in colloquial styles. Examples:

[šəbd]	~	[səbd]	~	[səbəd]	'word'
['šawas]	~	['sabas]			'bravo'
[kəṣṭ]	~	[kəsṭ]			'pain'
['kəṛa]	~	['kəra]			'hard'
[maṛ]	~	[mar]			'liquid accompanying boiled rice'
['əwətar]	~	['əbətar]	~	['əptar]	'incarnation'
['yadəb]	~	['ǰadəb]			'a family name'
['čərya]	~	['čərja]			'routine'

A tentative sociolinguistic stylistic rule, following M.Ohala (1972: 14) is introduced to account for these variations that characterize Maithili phonology:

S-Rule

$$\begin{bmatrix} \text{ṇ} \\ \text{š/ṣ} \\ \text{ṛ} \\ \text{w} \\ \text{y} \end{bmatrix}_i \rightarrow \begin{bmatrix} \text{n} \\ \text{s} \\ \text{r} \\ \text{b} \\ \text{ǰ} \end{bmatrix}_i \; / \; \underline{\qquad} \; [\text{colloquial/less elegant style}]$$

2.3.5. Unit Versus Cluster

The issue of units vs. cluster has been discussed in detail in Yadav (1976), wherein it was demonstrated that the Maithili stops and affricates of all four manners should be treated as units rather than clusters for the simple reason that they show full phonological opposition in all positions. As regards resonants (i.e., nasals, taps, and laterals) which show a two-way phonetic contrast between aspirated and unaspirated, it was argued that the phonetically aspirated resonants should be treated as clusters rather than units on grounds of:

(i) relative frequency of occurrence,
(ii) lack of distributional contrast initially,

(iii) free variation elsewhere,
(iv) syllabificational constraints, and finally,
(v) the native speaker's intuition about the language.

Some of the main arguments are summarized below:

Frequency

It is commonly held that it is useful to incorporate the information conveyed by the relative frequency of the phonemes of a language in its phonology. In this section, a count of the dictionary entries (D.Jha 1950) of Maithili initial phonemes and of Maithili resonants + h occurring in all positions is provided in order to determine the relative frequency of Maithili consonant phonemes. The number of entries in this dictionary totalled 12,603. The frequency of occurrence of Maithili consonant phonemes is given in Table 2.III. The total frequency of occurrence of Maithili resonant + h segments is presented in Table 2.IV.

Tables 2.III and 2.IV show that the five consonant phonemes with the highest frequency of occurrence in initial position are /b, k, s, p, m/ in that order; similarly the five most frequent aspirated phonemes are /b^h, k^h, p^h, $\check{c}^h$, g^h/ in that order. The sound segment which bears the lowest functional load in Maithili is [l^h], which occurs only 19 times in this dictionary.

Distribution

As is shown in section 2.2.2.1., Maithili stops and affricates show complete phonological contrasts in all positions. The resonnants, however, do not. Only unaspirated resonants occur initially, and medially aspirated resonants and resonants + h alternate with one another. Examples are given below:

[bə'r^haũ]	~	[bər'hau]	/bə$\underset{\cdot}{d}^h$au/	'please cause to move ahead'
['kəl^ha]	~	[kəlha]	/kəlha/	'adulterated (oil)
['kə$n^h\tilde{a}$]	~	['kənhã]	/kənha/	'shoulder'
['$\check{j}im^h$ər]	~	['$\check{j}$imhər]	/$\check{j}$imhər/	'a kind of tree'

Looking at the spectrographic wave forms of the phonetically aspirated resonants [r^h, l^h, m^h, n^h] and the resonant + h [rh, lh, mh, nh] clusters, the following observations can be suggested:

(i) aspirated resonants are characterized by an aspirated release (see Chapter 3);
(ii) the duration of the aspirated release is about 70-80 msec long;
(iii) the resonant + h combination is characterized by a clear voiced release of the resonant;
(iv) the duration of the h segment in the resonant + h cluster is about 100 msec -- the h segment being always about 20 - 30 msec longer than the duration of the aspirated release of the phonetically aspirated resonants.

No	*Phoneme*	*Frequency*
1	/b/	1082
2	/k/	1017
3	/s/	906
4	/p/	891
5	/m/	754
6	/č/	516
7	/g/	506
8	/d/	477
9	/n/	412
10	/t/	396
11	/ǰ/	386
12	/h/	383
13	/b^h/	381
14	/k^h/	369
15	/l/	354
16	/p^h/	256
17	/$č^h$/	253
18	/r/	252
19	/g^h/	215
20	/d^h/	214
21	/ṭ/	194
22	/$ǰ^h$/	193
23	/ḍ/	161
24	/$ṭ^h$/	114
25	/$ḍ^h$/	105
26	/t^h/	81

Table 2.III: Frequency of Maithili Phonemes

No	*Segment*	*Frequency*
1	[r^h]	159
2	[n^h]	42
3	[m^h]	37
4	[l^h]	19

Table 2.IV: Frequency of Maithili Resonant + h Segments

In the final position, Maithili resonants occur as shown below:

/baiḍ^h/	[baĭr^h]	'flood'
/bəḍ^h/	[bər^h]	'grow'

/kand^{h}/	[kan^{h}]			'shoulder'
/kail^{h}/	[kaĭl]	~	[kaĭl^{h}]	'tomorrow'
/k^{h}amb^{h}/	[k^{h}am]	~	[k^{h}am^{h}]	'pole'

Syllabificational Constraints

Syllable boundaries clearly demonstrate that the Maithili stop + h and affricate + h segments cannot be separated to form more than one syllable and hence ought to be treated as units. Consider the following examples ($ = syllable boundary):

['li$k^{h}əl]	'written; fated'
*[lik$həl]	
[bo$'k^{h}ar]	'fever'
*[bok$har]	
['k^{h}əb^{h}$ra]	'ditch'
*[k^{h}əb$hra]	
[kə$'ṭ^{h}al]	'name of a village'
*[kəṭ$hal]	
[b^{h}o$'t^{h}ar]	'cause to blunt'
*[b^{h}ot$har]	
['ka$'č^{h}i]	'tight underwear'
*[kač$hi]	

The resonant + h segments, which also surface as aspirated with syllable divisions like stops, however, have a syllable boundary between the two segments. Examples:

[nə$'r^{h}er]	~	[nər$'her]		'vagabond'
['k^{h}ə$m^{h}a]	~	['k^{h}əm$ha]		'pole'
['kə$n^{h}a]	~	['kən$ha]		'shoulder'
['pi$l^{h}i]	~	['pil$hi]		'jaundice'
['kə$l^{h}a]	~	['kəl$ha]		'adulterated oil

Thus, the system of constraints that operate on syllabic division suggests that the Maithili resonant + h segments ought to be treated as clusters rather than as units. Such an analysis also appeals to the intuition of a native speaker.

Thus in this analysis I shall derive most aspirated resonants [R^{h}] (where *R* denotes any resonant) from /Rh/ sequences. Where a stop intervenes, however, as in /kand^{h}/ ⟶ [kan^{h}] 'shoulder', the underlying sequence includes an aspirated stop: /RS^{h}/ (where *S* denotes any stop).

To account formally for the Maithili resonants which are phonetically aspirated and never occur as resonant + h, two phonological rules are presented. The phonological rules, written in distinctive features (see Section 2.4.), are given below with sample derivations for illustration:

P-rule 1

$$\begin{bmatrix} - & \text{anterior} \\ + & \text{coronal} \\ - & \text{high} \\ + & \text{voice} \\ + & \text{aspiration} \end{bmatrix} \longrightarrow [+ \text{ sonorant}] \;/\; V_____(\#)$$

P-rule 1 says that word-finally and postvocalically all /ḍ^{h}/ become [r^{h}] in Maithili.

P-rule 2

$$\begin{bmatrix} + & \text{consonantal} \\ + & \text{nasal} \\ \alpha & \text{anterior} \\ -\alpha & \text{back} \\ \beta & \text{coronal} \end{bmatrix} \quad \begin{bmatrix} + & \text{consonantal} \\ + & \text{voice} \\ + & \text{aspirated} \\ \alpha & \text{anterior} \\ -\alpha & \text{back} \\ \beta & \text{coronal} \end{bmatrix} \quad \#$$

$$1 \qquad\qquad 2 \qquad 3 \rightarrow \quad 1 \quad \emptyset \quad 3$$

$$[+ \text{ asp}]$$

P-rule 2 is written in a transformational format and it says that in colloquial Maithili word-finally all /nd^{h}/, /mb^{h}/ and /ng^{h}/ become [n^{h}], [m^{h}] and [ŋ^{h}], respectively. /nd^{h}/, /mb^{h}/, and /ng^{h}/ never surface as such word-finally in colloquial pronunciations. The Greek-letter variables serve to exclude sequences of nasal + retroflex or nasal + palatal affricate from the domain of the rule. Nasal + retroflex sequences instead undergo P-rule 1. Nasal + voiced aspirated palatal sequences do not occur word finally in Maithili (see p.35). It should be membered, however, that in highly literate and educated styles, some native speakers may tend to pronounce the words as they are written: the Devanagari writing system now being used for Maithili does provide separate graphemes for /nd^{h}/, /mb^{h}/ and /ng^{h}/.

Sample derivations are given below:

Underlying forms	kand^{h}	k^{h}amb^{h}	səng^{h}	pəḍ^{h}	bəḍ^{h}əl
Assimilation rule	--	--	səŋg^{h}	--	--
P-rule 1	--	--	--	pər^{h}	bər^{h}əl
P-rule 2	kan^{h}	k^{h}am^{h}	səŋ^{h}	--	--
Surface forms	kan^{h}	k^{h}am^{h}	səŋ^{h}	pər^{h}	bər^{h}əl
	'shoulder'	'pole'	'association'	'read'	'(having) grown'

The situation with [l^h] is not clear. But then its functional load is low -- 19 occurrences out of 12,603 lexical entries --, and the dictionary provides the alternate form, i.e., [lh] in the case of intervocalic [l^h]. Here it is suggested that the phonetic aspiration of Maithili resonants can be understood better if it is viewed as an areal feature. After all, almost all the Sino-Tibetan languages (e.g., Newari, Tibetan) spoken in the region have an entire series of aspirated resonants as underlying phonemes. I shall therefore derive surface [l^h] from underlying /lh/, in keeping with my treatment of the other instances of [R^h] ~ [Rh].

It should be noted that in Maithili the surface contrast between an aspirated resonant and an unaspirated resonant is maintained only in those cases in which merger of minimal pairs would cause semantic merger and thereby increase homophony. Examples:

[kan^h]	'shoulder'
[kan]	'ear'
[bər^h]	'grow!'
[bər]	'bridegroom'

2.3.6. Consonant Clusters

The use of consonant clusters in Maithili, especially in initial and final positions, denotes a marked degree of formality and the speaker's knowledge of languages like Sanskrit, Hindi-Urdu and English. Uneducated speakers use the least number of clusters.

Maithili consonant clusters are shown in Tables 2.V - 2.VII. The following subsections list each cluster observed (some rare clusters may have been inadvertently omitted). Examples of words containing consonant clusters are given in broad phonetic transcription which does not always represent the actual pronunciation. The rules required to derive the surface phonetic forms are not discussed in this study.

C_1 \ C_2	p	p^h	b	b^h	t	t^h	d	d^h	ṭ	ṭ^h	ḍ	ḍ^h	č	č^h	ǰ	ǰ^h	k	k^h	g	g^h	s	h	r	l	m	n
p																							+	+		
p^h																										
b																							+			
b^h																							+			
t																							+			
t^h																										
d																							+			
d^h																							+			
ṭ																							+			

(continued)

C_1 \ C_2	p	p^h	b	b^h	t	t^h	d	d^h	ṭ	$ṭ^h$	ḍ	$ḍ^h$	č	$č^h$	ǰ	$ǰ^h$	k	k^h	g	g^h	s	h	r	l	m	n
t^h																										
d																							+			
d^h																										
č																										
$č^h$																										
ǰ																										
$ǰ^h$																										
k																							+	+		
k^h																							+	+		
g																							+	+		
g^h																							+	+		
s	+	+			+	+			+														+			
h																							+	+	+	+
r																							+			
l																										
m																										
n																							+	+		
																							+			

Table 2.V: Maithili Initial Consonant Clusters

C_1 \ C_2	p	p^h	b	b^h	t	t^h	d	d^h	ṭ	$ṭ^h$	ḍ	$ḍ^h$	č	$č^h$	ǰ	$ǰ^h$	k	k^h	g	g^h	s	h	r	l	m	n
p					+		+		+				+	+	+		+	+			+	+	+	+	+	+
p^h					+		+	+	+		+															
b																	+		+		+	+	+	+		+
b^h																					+	+	+	+		+
t	+		+														+		+		+	+	+	+		+
t^h																	+					+	+			+
d			+	+													+	+			+	+	+	+	+	+
d^h																					+		+	+	+	+
ṭ			+														+	+	+	+	+	+	+	+	+	+
$ṭ^h$	+				+												+	+			+	+	+	+	+	+
ḍ																	+	+	+		+	+	+	+	+	+
$ḍ^h$																	+	+	+	+	+	+	+	+	+	+
č			+		+																					
$č^h$			+		+																					
ǰ	+	+	+	+													+						+	+	+	+
$ǰ^h$																							+	+	+	+
k	+		+		+	+	+		+				+	+			+		+		+	+	+	+	+	+
k^h			+														+	+					+	+		+
g			+	+	+		+	+				+									+	+	+	+	+
																					+	+	+	+	+	+

(continued)

C_1 \ C_2	p	p^h	b	b^h	t	t^h	d	d^h	ṭ	$ṭ^h$	ḍ	$ḍ^h$	č	$č^h$	ǰ	$ǰ^h$	k	k^h	g	g^h	s	h	r	l	m	n
g^h									+														+	+		
s	+	+	+		+	+			+	+			+		+		+	+				+	+	+	+	+
h			+		+	+	+		+								+		+		+		+	+	+	+
r	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+		+	+	+
l	+	+	+						+				+		+	+	+	+	+		+	+	+		+	+
m	+	+	+	+	+			+	+				+	+		+	+			+	+	+	+	+		+
n	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+			+	+	+	+	+	

Table 2.VI: Maithili Medial Consonant Clusters

C_1 \ C_2	p	p^h	b	b^h	t	t^h	d	d^h	ṭ	$ṭ^h$	ḍ	$ḍ^h$	č	$č^h$	ǰ	$ǰ^h$	k	k^h	g	g^h	s	h	r	l	m	n
p					+																		+			+
p^h																							+			
b							+	+									+									
b^h																										
t																					+		+	+	+	+
t^h																										
d																							+		+	
d^h																										
ṭ																										
$ṭ^h$																										
ḍ																										
$ḍ^h$																										
č																										
$č^h$																										
ǰ																							+			
$ǰ^h$																										
k					+				+												+		+	+	+	
k^h					+																				+	
g								+									+						+			+
g^h																										+
s	+				+	+			+														+		+	+
h																										
r	+	+	+	+	+	+	+	+	+		+		+		+		+	+	+	+	+	+			+	
l	+	+					+				+						+					+			+	
m	+	+	+	+																		+	+	+		+
n					+		+	+	+		+	+	+				+				+	+			+	

Table 2.VII: Maithili Final Consonant Cluster

2.3.6.1. Initial Consonant Clusters

Two-Consonant Clusters

Stop + resonant

pr-	pran	'life'
br-	bramʰən	'brahmin'
bʰr-	bʰrəsṭ	'corrupt'
tr-	tran	'freedom'
dr-	driṣṭi	'look'
dʰr-	dʰritrasṭra	'a character in the Gita'
ṭr-	ṭren	'train'
ḍr-	ḍrama	'drama'
kr-	kriya	'action'
gr-	gram	'village'
gʰr-	gʰrina	'hatred'
pl-	plan	'plan'
kl-	klant	'sad'
gl-	glas	'glass'

[*s*] + *stop*

sp-	spəsṭ	'clear'
spʰ-	spʰəṭik	'marble'
st-	stən	'breast'
stʰ-	stʰan	'place'
sṭ-	sṭesən	'station'
sk-	skəndʰ	'section; chapter'

[*s*] + *resonant*

sr-	sriṣṭi	'creation'
sl-	sleṭ	'slate'
sm-	smərən	'memory'
sn-	snan	'bath'

Nasal + resonant

mr-	mriga	'deer'
nr-	nrip	'king'
ml-	mlan	'exhausted'

[*h*] + [*r*]

hr-	hras	'loss'

Three-consonant clusters

str-	stri	'wife; woman'
smr-	smriti	'memory'

2.3.6.2. Medial Consonant Clusters

Two-consonant clusters

Stop + stop

-pt-	həpta	'week'
-pd-	updes	'moral teaching'
-pṭ-	səpṭa	'carpet'
-pč-	kəpči	'miser'
-pč^{h}-	upč^{h}əl	'(having) drained e.g. water)'
-pǰ-	upǰəl	'(having) grown'
-pk-	upkar	'favor'
-pk^{h}-	bəpk^{h}əuki	'Father-eater (feminine) -- a way of calling names'
-bt-	əbtar	'incarnation'
-bd-	gubdi	'quiet'
-bd^{h}-	əbd^{h}i	'name of a person'
-bṭ-	səbṭa	'all of it'
-bḍ-	kəbḍi	'a kind of a game'
-bk-	əbkas	'leave'
-bg-	əbgun	'defect'
-b^{h}k-	ləb^{h}ka	'the new one'
-tp-	tətpər	'ready'
-tb-	kotbakotbi	'a Muslim celebration'
-tk-	čəmətkar	'skill'
-tk^{h}-	b^{h}ətk^{h}əi	'the ritual of eating rice' - a feast
-db-	kodba	'smallpox'
-db^{h}-	ədb^{h}ut	'wonderful'
-dk-	bədk^{h}əi	'criticism'
-dk^{h}-	səidk^{h}ən	'always'
-dg-	udgəm	'source'
-dg^{h}-	udg^{h}aṭən	'opening ceremony'
-d^{h}k-	əd^{h}kari	'owner; master'
-d^{h}k^{h}-	əd^{h}k^{h}əi	'half meal'
-ṭb-	kəṭbi	'an ornament'
-ṭk-	č^{h}oṭki	'the small one (feminine)'
-ṭk^{h}-	nəṭk^{h}əṭ	'naughty'
-ṭg-	kəṭgər	'shapely'
-ṭ^{h}p-	kəṭ^{h}pǰ	'sore with puss'
-ṭ^{h}t-	səṭ^{h}ta	'will send (a gift)'
-ṭ^{h}k-	bəiṭ^{h}ki	'meeting'
-ṭ^{h}k^{h}-	kəṭ^{h}k^{h}od^{h}i	'woodpecker'
-ṭ^{h}g-	kəṭ^{h}gər	'hard'
-ṭ^{h}g^{h}-	kəṭ^{h}g^{h}əra	'a child game (lit. wooden house)'

-čb-	sočbəi	'(I) will think'
-čt-	pəčta	'will innoculate'
-čk-	ləčki	'swing'
-čʰb-	pəčʰba	'western (wind)'
-čʰt-	pəčʰta	'the late one'
-ǰp-	rəǰput	'the warrior caste'
-ǰpʰ-	rəǰpʰul	'a flower (befitting a king)'
-ǰb-	səǰba	'fresh (yogurt)'
-ǰbʰ-	raǰbʰog	'a kind of mango'
-ǰk-	raǰkul	'of royal descent'
-ǰg-	əǰgər	'python'
-ǰʰk-	səũǰʰka	'of the evening'
-ǰʰkʰ-	sãǰʰkʰən	'in the evening'
-kp-	nəkpičča	'one with a flattened nose'
-kb-	ləkba	'paralysis'
-kt-	mukti	'liberation'
-ktʰ-	əktʰæl	'careless; too much satisfied'
-kd-	təkdir	'fate'
-kt-	ə̃kṭa	'unrefined (rice)'
-kč-	nəkčira	'one with a cut in the nose'
-kčʰ-	kəkčʰəl	'dissatisfied; anguished'
-kʰb-	əkʰbar	'newspaper'
-kʰt-	təkʰta	'wooden board'
-kʰd-	sukʰdeb	'name of a person'
-kʰṭ-	kʰəkʰṭəl	'dirty and dry (utensil)'
-kʰṭʰ-	sukʰṭʰi	'dried (fish, meat, etc.)'
-gb-	bʰəgbe	'(You) will run away'
-gbʰ-	ləgbʰəg	'about'
-gt-	bʰəgta	'a witch doctor'
-gd-	bəgdəl	'spoiled'
-gdʰ-	mugdʰa	'a happy woman'
-gʰṭ-	bigʰṭəl	'angry'

Stop + fricative

-ps-	ǰʰəpsi	'cloudy and rainy'
-pʰs-	əpʰsər	'officer'
-bs-	əbsər	'occasion'
-ts-	utsəb	'celebration'
-tʰs-	həthsar	'a house for elephant'
-ds-	bədsahi	'a kind of sweet'
-dʰs-	ədʰsera	'a measure for half a seer'

	čəṭsar	'students' study room'
-ṭs-	əṭʰsəitʰ	'sixty-eight'
-ṭʰs-	rajsi	'royal'
-js-	kəksəl	'tight'
-ks-	nəkʰsikʰ	'from top to toe'
-kʰs-		

Stop + resonant

-pr-	uprag	'complaint'
-pʰr-	pʰepʰra	'lungs'
-br-	ləbra	'naughty'
-bʰr-	kʰəbʰra	'ditch'
-tr-	sutri	'thin thread'
-tʰr-	pətʰrah	'stony'
-dr-	bədri	'shower'
-dʰr-	sudʰrəl	'reformed'
-ṭr-	leṭra	'left-handed'
-ṭʰr-	koṭʰri	'room'
-čr-	pəčra	'nail'
-čʰr-	pəčʰra	'quarrel'
-jr-	bəjra	'wrestling'
-jʰr-	ojʰrəl	'entangled'
-kr-	kəkri	'a kind of cucumber'
-kʰr-	kʰəkʰri	'paddy without rice'
-gr-	gəgri	'small pitcher'
-gʰr-	gʰəgʰri	'skirt'
-pl-	toplaha	'the covered one'
-pʰl-	sipʰlah	'dressy'
-bl-	əbla	'helpless'
-tl-	titli	'butterfly'
-tʰl-	hutʰlək	'ridiculed'
-dl-	bədla	'revenge'
-dʰl-	ədʰlah	'bad'
-ṭl-	həṭli	'(I) moved'
-ṭʰl-	bəiṭʰli	'(I) sat'
-čl-	pəčli	'(I) vaccinated'
-čʰl-	məčʰli	'fish'
-jl-	bijli	'electricity'
-jʰl-	məijʰli	'middle (feminine)'
-kl-	nəkli	'artificial'
-kʰl-	dekʰli	'(I) saw'
-gl-	bəgli	'pocket'
-gʰl-	pigʰləl	'melted'
-pm-	əpman	'insult'
-tm-	tətma	'an untouchable caste'
-tʰm-	prətʰma	'first'
-dm-	ədmi	'man'
-dʰm-	udʰmi	'naughty'
-ṭm-	kʰəṭməl	'bed bug'

-tʰm-	əṭʰma	'eighth'
-čm-	pə̌čmi	'fifth'
-čʰm-	pəičʰmaha	'western'
-ǰm-	həǰma	'barber'
-km-	hukmi	'the ordering type'
-kʰm-	sukʰmi	'rich and happy'
-gm-	ləgma	'name of a village'
-pn-	səpna	'dream'
-pʰn-	pʰəpʰnah	'inflamatory'
-bn-	ləbni	'a small pot'
-bʰn-	bəbʰna	'brahmin'
-tn-	potna	'rag used to clean, paint, etc.
-tʰn-	sutʰni	'a kind of sweet potato'
-dn-	ədna	'trifle'
-dʰn-	ləḍʰni	'load-carrying horse'
-ṭn-	kəṭni	'harvest'
-ṭʰn-	səṭʰnihar	'giver (e.g., of a gift)'
-čn-	bečni	'name of a female person'
-čʰn-	ləčʰni	'lucky'
-ǰn-	səǰni	'beloved'
-ǰʰn-	bəǰʰnai	'the act of entanglement'
-kn-	bukni	'chili powder'
-kʰn-	kəkʰni	'when'
-gn-	əgni	'fire'

Stop + [h]

-ph-	uphar	'gift'
-pʰh-	kəpʰha	'that which causes cough'
-bh-	ləbhi	'bring (imp.)'
-bʰh-	jʰəbʰhi	'milking pot'
-th-	bʰuthi	'ghostly'
-dh-	bədhi	'a thread worn around neck'
-dʰh-	əḍʰhi	'the half one'
-ṭh-	ləṭha	'thin and weak'
-ṭʰh-	əṭʰhətair	'seventy_eight'
-ǰh-	səǰha	'joint'
-kh-	kəkhəl	'combed'
-kʰh-	dəkʰhi	'see (imp.)'
-gh-	ləghi	'urine'

[s] + *stop*

-sp-	əspətal	'hospital'
-sp^{h}-	bisp^{h}oṭ	'explosion'
-sb-	əsbab	'pomp'
-st-	rəsta	'path'
-st^{h}-	prəst^{h}an	'departure'
-ṣṭ-	biṣṭi	'loin cloth'
-ṣṭ^{h}-	k^{h}əṣṭ^{h}i	'sixth'
-sč-	pəsčim	'west'
-sǰ-	məsǰid	'mosque'
-sk-	əskər	'alone'
-sk^{h}-	nusk^{h}a	'way out'

s + resonant

-sr-	tesra	'third'
-sl-	əslil	'obscene'
-sm-	čəsma	'spectacles'
-sn-	bəsni	'a small pitcher'

[s] + [*h*]

-sh-	məshur	'famous'

Resonant + stop

-rp-	k^{h}urpi	'a small spade'
-rp^{h}-	bərp^{h}i	'a cold sweet'
-rb-	pərba	'pigeon'
-rb^{h}-	gərb^{h}u	'name of a person'
-rt-	pərti	'barren land'
-rt^{h}-	kurt^{h}i	'a kind of lentil'
-rd-	hərdi	'turmeric'
-rd^{h}-	gobərd^{h}ən	'name of a mountain'
-rṭ-	parṭi	'party'
-rṭ^{h}-	sorṭ^{h}a	'an old folk song'
-rč-	mirčai	'hot pepper'
-rč^{h}-	kərč^{h}ul	'a large spoon'
-rǰ-	kərǰa	'loan'
-rǰ^{h}-	murǰ^{h}əl	'faded'
-rk-	lərki	'daughter'
-rk^{h}-	bərk^{h}i	'death anniversary'
-rg-	murga	'cock'
-rg^{h}-	kərg^{h}a	'loom'
-lp-	jəlpan	'refreshment'
-lp^{h}-	sulp^{h}a	'heavy needle'
-lb-	bulbul	'nightingale'
-lṭ-	ulṭa	'opposite'
-lč-	lalči	'greedy'
-lǰ-	kəlǰug	'one of the four Yugas'

-lǰʰ-	ulǰʰəl	'entangled; busy'
-lk-	ḍʰolki	'small drum'
-lkʰ-	ǰəlkʰəi	'refreshment'
-lg-	əlgəl	'swollen'
-mp-	čəmpa	'name of a female person'
-mpʰ-	ḍəmpʰa	'huge drum'
-mb-	ləmba	'long'
-mbʰ-	kʰəmbʰa	'house pole'
-mt-	gumti	'railroad crossing'
-mdʰ-	səmdʰi	'in laws'
-mṭ-	čimṭa	'tongs'
-mč-	čəmča	'spoon'
-mčʰ-	gəmčʰa	'towel'
-mǰʰ-	səmǰʰəl	'understood'
-mk-	gəmki	'fragrance'
-mgʰ-	təmgʰəil	'a brass pitcher'
-np-	kənpəṭṭi	'side of the face'
-npʰ-	kənpʰul	'earring'
-nb-	ənbe	'(You will) bring'
-nbʰ-	bənbʰoǰ	'picnic'
-nt-	ənṭə	'elsewhere'
-ntʰ-	məhəntʰa	'name of a person'
-nd-	əndaǰ	'guess'
-ndʰ-	dʰəndʰa	'job'
-nṭ-	gʰənṭa	'huge bell'
-nṭʰ-	bənṭʰa	'pigmy'
-nḍ-	ḍənḍa	'a heavy stick'
-nč-	unčalis	'forty-nine'
-nčʰ-	kančʰa	'a common name for a Nepali-speaking waiter'
-nǰ-	bʰanǰa	'nephew'
-nk-	nənkirba	'little boy'
-nkʰ-	kənkʰi	'wink'

Resonant + s

-rs-	kursi	'chair'
-ls-	alsi	'lazy'
-ms-	ǰʰəmsi	'cloudy and rainy'
-ns-	munsa	'male'

Resonant + resonant

-rl-	girla	'fell down'
-rm-	gərmi	'heat'
-rn-	kərni	'act'
-lr-	dulra	the loved one'
-lm-	məlməl	'muslin'
-ln-	pʰəlna	'some one (masculine)'
-mr-	čəmra	'skin'

-ml-	əmli	'tamarind'
-mn-	rəmj̆^{h}imni	'okra'
-nr-	bənri	'monkey (female)
-nl-	bənli	'(I) became'
-nm-	j̆ənməl	'born'

[h] + stop

-hb-	kəhba	'coffee'
-ht-	kəhta	'will tell'
-ht^{h}-	məht^{h}a	'a family name'
-hd-	bəhdi	'personal name'
-hṭ-	bəhṭa	'drive the animals (imp.)'
-hk-	gə̃hki	'buyer'
-hg-	kəihgel	'came and said'

[h] + [s]

-hs-	təhsil	'revenue'

[h] + resonant

-hr-	k^{h}əhru	'go down (honorific + Imp.)'
-hl-	kəhlək	'said'
-hm-	rəhməl	'personal name'
-hn-	mohni	'attractive'

Three-consonant cluster

-str-	mistri	'mechanic'

2.3.6.3. Final Consonant Clusters

Stop + stop

-pt	gupt	'secret'
-bd	səbd	'word'
-bd^{h}	ləbd^{h}	'obtained'
-bj̆	kəbj̆	'constipation'
-kt	b^{h}əkt	'devotee'
-kṭ	ækṭ	'act'
-k^{h}ṭ	sək^{h}ṭ	'strictly'
-gd^{h}	mugd^{h}	'pleased'
-gj̆	mə̤gj̆	'mind'

Stop + [s]

-ts	bib^{h}əts	'grotesque'
-ks	səks	'person'

Stop + resonant

-pr	bipr	'brahmin'
-br	kəbr	'graveyard'
-tr	mitr	'friend'
-dr	səmudr	'ocean'
-ǰr	bəǰr	'thunder'
-čr	čəkr	'circle'
-gr	əgr	'ahead'
-tl	kətl	'massacre'
-kl	əkl	'intelligence'
-tm	k^hətm	'end'
-dm	pədm	'lotus'
-km	hukm	'order'
-k^hm	ǰək^hm	'wound'
-pn	swəpn	'dream'
-tn	rətn	'jewel'
-gn	nəgn	'naked'
-g^hn	big^hn	'trouble'

[s] + stop

-sp	dilčəsp	'interesting'
-st	əst	'end'
-st^h	əntəst^h	'interior'
-sṭ	əsṭ	'eight'

[s] + resonant

-sr	misr	'a family name'
-sm	b^{h}əsm	'ashes'
-sn	prəsn	'question'

Resonant + stop

-rp	dərp	'pride'
-rp^h	bərp^h	'snow'
-rb	dərb	'valuable goods'
-rb^h	gərb^h	'pregnancy'
-rt	sərt	'condition'
-rt^h	ərt^h	'meaning'
-rd	sərd	'cold'
-rd^h	ərd^h	'half'
-rṭ	sərṭ	'shirt'
-rḍ	garḍ	'guard'
-rč	čərč	'reference'
-rǰ	kərǰ	'loan'
-rk	p^{h}ərk	'difference'
-rk^h	murk^h	'stupid'
-rg	bərg	'class'
-rg^h	dirg^h	'long'

-lp	əlp	'little'
-lp^h	ǰulp^h	'lock of hair'
-ld	ǰəld	'soon'
-ld	phild	'field'
-lk	sulk	'fee'
-mp	b^{h}ukəmp	'earthquake'
-mp^h	ḍəmp^h	'huge drum'
-mb	kədəmb	'a kind of tree'
-mb^h	dəmb^h	'vanity'
-nt	sənt	'sage'
-nd	bənd	'closed'
-nd^h	bənd^h	'dam'
-nṭ	ənṭsənṭ	'haphazard'
-nḍ	ḍənḍ	'punishment'
-nḍ^h	lənḍ^h	'male organ'
-nč	pənč	'leader; arbiter'
-nǰ	kunǰ	'forest'

Resonant + [s]

-rs	bərs	'year'
-ns	həns	'swan'

Resonant + resonant

-rm	gərm	'hot'
-lm	julm	'injustice'
-mr	umr	'age'
-ml	əml	'sour'
-mn	prədyumn	'lotus'
-nm	ǰənm	'birth'

Resonant + [h]

-rh	bairh	'flood'
-lh	kailh	'tomorrow/yesterday'
-mh	brəmh	'God'
-nh	činh	'mark'

2.3.7. Vowel Clusters

Maithili two-vowel clusters are listed in Table 2:VIII. A few of the possible three-vowel clusters are also listed in section 2.3.7.2. Both types of vowel clusters undergo a low level phonetic rule of the type shown below:

$$V_1V_2(V_3) \longrightarrow V_1\breve{V}_2(V_3)$$

where

V_2 is [i u e].

V_2 / V_1	i	e	æ	ə	a	ɔ	o	u
i			+	+	+		+	+
e								+
æ								
ə	+	+			+			+
a	+	+					+	+
ɔ								
o	+	+			+			
u	+				+			

Table 2.VIII: Maithili Vowel Clusters

2.3.7.1 Two Vowel Clusters

Initial

ə i-	əisən	'like this'
ə e-	əela	'came (honorific)'
ə u-	əuta	'will come (honorific)'
ai-	aiskrim	'ice cream'
oi-	oisən	'like that'

Medial

-iæ-	k^{h}iæl	'defaced (e.g., coin)'
-iə-	siəl	'sewn'
-ia-	diad	'kin'
-io-	dior	'husband's brother'
-iu-	piusi	'father's sister'
-eu-	ḍeur^{h}i	'court'
-əi-	bəis	'sit (imp.)'
-əe-	bəel	'ox'
-əu-	čəuh	'jaw'
-ai-	bail	'crop'
-ae-	lael	'brought'
-au-	baul	'sand'
-oi-	koila	'coal'
-oe-	goenka	'a family name'
-oa-	poar	'straw'
-ui-	buir	'vagina'
-ua-	juari	'gambler'

Final

-iə	diə	'(please) give'
-ia	dia	'lamp'
-io	dio	'(let him) give'
-iu	g^{h}iu	'clarified butter'
-əi	ləi	'paste'
-əe	gəe	'a form of adress for women'
-əa	dəa	'deliver and come'
-əu	həu	'a form of adress for men'
-ai	lai	'popped riced balls'
-ae	mae	'mother'
-ao	lao	'(let him) bring'
-au	bau	'father'
-oi	koi	'any person'
-oa	koa	'slice'
-ui	sui	'needle'
-ua	ǰua	'gambling'

2.3.7.2. Three-Vowel Clusters

Medial

-iau	piauǰ	'onion'
-əuæ-	bəuæl	'lost'

Final

-iəu	diəu	'give (imp.)'
-iau	biau	'give birth (imp.)'
-əia	'dəia	'grandmother'
-əua	kəua	'crow'
-uia	buia	'louse'

2.4. DISTINCTIVE FEATURES

The analysis of the contrasting segments of Maithili at the systematic phonemic level into distinctive features results in the matrix in Table 2.IX. The feature system used is that of Chomsky and Halle (1968) modified in the ways proven necessary in this study. Treatment of aspiration is especially affected.

2.4.1. Segment Structure Conditions

The feature values in parentheses in Table 2.IX are those which are predictable by segment structure conditions (Stanley 1967). Values which cannot be specified are left blank (see Henderson,

	i	e	æ	a	ə	ɔ	o	u	ĩ	ẽ	æ̃	ã	ə̃	ɔ̃	õ	ũ	p	p^{h}	b	b^{h}	ṭ	ṭ^{h}	ḍ	ḍ^{h}	ṭ	ṭ^{h}	ḍ	ḍ^{h}	č	č^{h}	ǰ	ǰ^{h}	k	k^{h}	g	g^{h}	s	r	l	m	n	h
Sonorant	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Consonantal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–
High	+	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	+	(–	–	–	–	–	–	–	–)	–	–	–	+	+	+	+	(+	+	+	+)	(–	–	–	–	–	–)
Low	(–)	–	+	+	–	+	–	(–)	(–)	–	+	+	–	+	–	(–)	(	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–)
Back	–	–	–	+	+	+	+	+	–	–	–	+	+	+	+	+	(	–	–	–	–	–	–	–	–	–	–	–)	–	–	–	+	+	+	+	(–	–	–	–	–	–)
Round	–	–	–	–	–	+	+	+	–	–	–	–	–	–	+	+	(	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–)
Nasal	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	(	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–)	–	–	+	+		
Lateral																					(–	–	–	–	–	–	–	–	–)								–	+				
Anterior																	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	(+	+	+)	+	+				
Coronal	(	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–)	–	–	–	+	+	+	+	+	+	+	+	+	+	–	–	–	–	(+	+	+)	–	+				
Continuant																	(–	–	–	–)	–	–	–	(–	–	–	–	–	–	–	–)	+			(+)						
Voice	(+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+)	–	–	+	+	–	–	+	+	–	–	+	+	–	–	+	+	–	–	+	+	(–)	(+	+	+	+	–)
Aspiration	(	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–)	–	+	–	+	–	+	–	+	–	+	–	+	–	+	–	+	–	+	–	+	(–	–	–	–	–)

Table 2.IX: Distinctive Features of Maithili Phonemes

1976:321-5). Some of the main redundancy conditions are stated below in Stanley's (p.426) if-then condition format.

1. I(c) [+ sonorant]
   ↓
   T(c) [+ voice]

The above condition states that in Maithili there are no voiceless or murmured vowels (oral or nasalized), liquids or nasals at the systematic phonemic level.

2. I(c) [+ sonorant]
   ↓
   T(c) [- aspiration]

This segment structure condition states that in Maithili there are no aspirated vowels, laterals or nasals at the systematic phonemic level.

3. I(c) $\begin{bmatrix} - \text{ sonorant} \\ + \text{ consonantal} \\ + \text{ continuant} \end{bmatrix}$
   ↓
   T(c) $\begin{bmatrix} - \text{ voice} \\ + \text{ anterior} \\ + \text{ coronal} \end{bmatrix}$

The above condition states that the only consonantal fricative in Maithili is /s/. /h/ is [- consonantal] and is not affected by Condition 3.

4. I(c) [+ anterior]
   ↓
   T(c) [- high]

This condition states that [p p^h b b^h; t t^h d d^h; s] are also [- high] in Maithili.

5. I(c) $\begin{bmatrix} [+ \text{ back}] \\ [+ \text{ consonantal}] \end{bmatrix}$
   ↓
   T(c) [+ high]

On the other hand, segment structure condition 5 states that Maithili [k k^h g g^h] are also [+ high].

2.5. CONCLUSION

Forty-two contrasting segments of Maithili have been established: it is argued that the phonetically aspirated resonants of Maithili should be treated as clusters rather than units. The phonemes of Maithili have also been analyzed into their distinctive features. Finally some tentative segment structure conditions have also been stated.

3 FIBEROPTIC STUDY OF VOICING AND ASPIRATION

3.1. GENERAL REMARKS

Aspiration and voicing are known to cooccur as mutually independent dimensions in a number of languages of the world. Indo-Aryan and West African languages are commonly cited as examples. There has been, however, considerable confusion in the description of the relationship between voicing and aspiration. Lisker and Abramson (1972:367) concluded that:

> By and large, much of what is said to be known about the management of stop voicing and aspiration is more hypothetical than data-based, and where there are data, they are more often than not derived from nonsense exercise of the speech mechanism whose relation to running speech is not clear.

3.1.1. Previous Studies

Phoneticians in ancient India studied aspiration in relation to the voicing process and distinguished the following categories:

Sanskrit Term		*Modern Phonetic Category*
śvāsa	'breath'	voiceless
nāda	'voice'	voiced
mahāprāṇa	'big breath'	aspirated
alpaprāṇa	'little breath'	unaspirated

(Allen 1953, Varma 1929)

Following this analysis Sanskrit and other Sanskritic languages would be described as having a series of stops which could be voiced or voiceless, aspirated or unaspirated, as shown in a matrix below.

	Unaspirated	Aspirated
Voiceless	p t ṭ etc.	p^h t^h $ṭ^h$ etc.
Voiced	b d ḍ etc.	b^h d^h $ḍ^h$ etc.

Traditionally, in the western phonetic literature, too, aspiration has been defined as an extra "puff of air" or "breath". As a matter of fact, most introductory textbooks on phonetics use this "puff of air" description of aspiration. But Ladefoged (1971:9-10) claims that this definition lacks precision in that no one-to-one physiological correlate to the extra "puff of air" could be established. He argues:

> There are at least two possibilities as to how this extra puff of air might be produced: it could be the result of an extra push from the respiratory muscles, or it could be due to a valvelike action of the glottis allowing more air to be released.

Consonant with the "puff of air" theory is the view which describes aspiration in terms of the rate of airflow. Ladefoged (1976: 162) in a recent article on Igbo has speculated that

> a better solution might be to revert to an older phonetic tradition, and define aspiration in terms of the rate of airflow.

Indeed there is normally a greater airflow for aspirated sounds than unaspirated, as for example, shown by Nihalani (1975a) for Sindhi. However, Kim (1965) found greater airflow for the Korean voiceless tense stops (which are never considered aspirated) than for the voiceless slightly aspirated stops. Greater airflow alone, then, is not a sufficient condition for aspiration.

Aspiration has also been attributed to greater subglottal air pressure (Chomsky and Halle, 1968:326). However, Ohala and Ohala (1972) have shown that in Hindi aspiration is not always accompanied by increased subglottal pressure. The same inconsistency can be seen in Nihalani's (1974) data for Sindhi.

Two additional physiological mechanisms -- (i) velopharyngeal opening and (ii) expansion of the walls of the supraglottal cavity -- have also been suggested as critical factors in the description of voiced and voiced aspirated stops of Sindhi (Nihalani 1975b). Nihalani concluded that

> . . . 'voiced' and aspirated voiced sounds in Sindhi are characterized by airflow leakage through an incomplete velopharyngeal closure so as to absorb the transglottal airflow and thus prevent the rise in the supraglottal pressure so as to maintain vibration. In the case of affricated palatal stops, the other device -- expansion of the walls of supraglottal cavities -- is employed in order to maintain the vocal fold activity. (p.101)

Lisker and Abramson (1964), in an effort to arrive at a single phonetic dimension that might serve as a basis for separating the various manner categories of initial stops in a number of languages including Hindi and Marathi, defined aspiration as "the automatic concomitant of a large delay in voice onset" (p.387). They defined the voice onset time (VOT) as the temporal relation between the onset of glottal pulsing and the release of the initial stop, and explained aspiration as a "voicing lag", i.e., a period of voicelessness intervening between the stop release and the onset of voice for the following vowel.

Lisker and Abramson's findings, no doubt, proved highly valuable and insightful for the characterization of a number of "two

category" and "three category" languages, but as they themselves admit, VOT fails to properly account for the "four category" languages:

> The two four-category languages, Hindi and Marathi, present us with our only clearcut cases in which the measure of voice onset time is insufficient for distinguishing among all the stop categories of a language . . . (p.403).

The inadequacy of the VOT as a single dimension to distinguish the manner categories of the stops of Indo-Aryan languages, like Hindi and Marathi, becomes self-evident when one tries to deal with the aspirated and unaspirated distinctions in the final positions which can clearly be differentiated by Hindi listeners (Ahmed and Agrawal, 1969; Gupta et al. 1969; Gupta and Ahmad, 1975; Bhatia 1973, 1976). Since there is no voicing following these stops, VOT criteria cannot strictly be applied, although Abramson (1976:108/reprint, 1977) seems to suggest that nonwithstanding that:

> VOT is an utterance-initial manifestation . . . , [it would be possible to] argue reasonably that word final aspiration is an instance of voice onset time. To produce aspiration in final position, it is necessary to release the stop, thus articulating an unstressed additional syllable (or perhaps "pseudosyllable").

In a cineradiographic study of Korean stops, Kim (1970) defined aspiration as a "function of the glottal opening at the time of release" (p.111). He noted that in Korean the glottal width at the time of the articulatory release was much greater for aspirated than for non-aspirated stops; Kim (1970:112) states:

> What is controlled by the laryngeal muscles in the case of aspiration is not the timing of the glottal closing (Lisker and Abramson's view) but the size of the glottal opening.

According to Kim, the voicing lag observed by Lisker and Abramson (1964) is caused by the fact that it takes longer to close a wide glottis than a narrow one. Because he was investigating Korean, which has only voiceless stops, Kim (1970) did not address his attention to the voiced aspirates.

Ladefoged (1971; 1974; 1975), probably basing his conclusions on the works of Lisker and Abramson (1964), Catford (1964) and the still photographs of the larynx taken by John Ohala and Ralph Vanderslice, chose to use a feature of voice onset time to distinguish voiced, voiceless unaspirated and voiceless aspirated, and to use phonation types (voice and murmur) to distinguish voiced unaspirated from voiced aspirated. Ladefoged (1973:80) describes Hindi stops as possessing the following degrees of:

		d	t	ḍ(d^h)	t^h
(a)	glottal stricture	5	2	3	1
(b)	voice onset	1	2	3	3

The above feature specification may be interpreted as follows:

	Close	*Narrow*	*Posterior Opening*	*Open*
Glottal Stricture During Closure	b,d,etc.	p,t,etc.	b^h,d^h,etc.	p^h,t^h,etc.

	Before Release	*At Release*	*Delayed Release*
Onset of Normal Voicing	b,d,etc.	p,t,etc.	b^h,d^h,etc. p^h,t^h,etc.

More recently, Catford (1977:113) has suggested that voice onset time can be used for the voiced aspirates as well as the voiceless if it is redefined as:

> delayed onset of normal voicing: the fact is that in such sounds as [bh] there is *whispery voice* rather than voice during the stop and for a certain period after its release. Just as with voiceless aspirated stops, there is thus a delay in the onset of normal voice.

3.1.2. Previous Fiberoptic Studies

Since Sawashima and Hirose (1968) first reported on a new laryngoscopic technique using fiberoptics, the glottal opening during the production of various types of speech sounds has been studied in a number of languages.

Stops

Observations of glottal activity during stop production have been reported for English by Sawashima et al. (1970), Lisker et al. (1970), and Cooper et al. (1971); for Korean by Hirose et al. 1974), and Kagaya (1971, 1974); for Japanese by Sawashima (1968). Sawashima and Niimi (1974), and Niimi and Sawashima (1974); for Hindi by Kagaya and Hirose (1975); for Tibetan by Kjellin (1977); and for stops produced by a phonetician by Hirose et al. (1972).

These studies have all shown that voiceless unaspirated stops have a narrower glottal opening than voiceless aspirated stops. Furthermore, the point of greatest glottal width for unaspirated stops occurs in the middle of the stop closure period whereas for aspirated stops it occurs near the point of oral release. Voiced (unaspirated) stops are produced with no arytenoid separation and with no interruption of glottal vibration. However, in one study, Lisker et al. (1970) reported that a few positional variants of

English voiced bilabial stop [b] showed no glottal vibration, while some voiceless bilabial and velar stops [p, k] showed no separation of the arytenoids, and some even showed no interruption of the glottal vibration.

Only the studies of Hindi and of stops produced by a phonetician included voiced aspirated stops. Both of these studies reported glottal abduction during the voiced aspirated stop. For Hindi, Kagaya and Hirose (1975) noted a posterior opening while the anterior portion remained adducted and vibrating. For the voiced aspirate produced by a phonetician, Hirose et al. (1972) reported that the glottal abduction occurred later than for voiceless aspirate and non-aspirate, reached its maximum later than for the voiceless aspirate, but was of about the same duration as for the voiceless aspirated. Only the studies of Japanese included geminate stops, which reported greater glottal opening for the geminate than for the non-geminate.

Affricates

Affricate production has also been studied in English by Sawashima et al. 1970); in Korean by Kagaya (1974); and in Japanese by Sawashima and Niimi (1974).

These investigations revealed that the friction portion of the voiced affricate was produced with a slight separation of the arytenoids and a slightly open glottis, while the voiceless unaspirated and aspirated affricates, like stops, were clearly distinguishable in terms of glottal width during their release. Furthermore, as in stops, greater glottal abduction was observed in Japanese for the geminate affricate than for the non-geminate.

Fricatives

Observations of laryngeal dynamics during fricative production also have been reported for English by Sawashima et al. (1970); for Korean by Kagaya (1974); for Japanese by Sawashima (1968), Sawashima and Niimi (1974), and Niimi and Sawashima (1974); and for Tibetan by Kjellin (1977).

These studies have revealed that the voiceless fricatives have glottal abduction with a wide glottis, while the voiced fricatives have closed arytenoids and vocal fold vibration. Only one study (Sawashima, 1968) reported glottal abduction with a slightly open glottis for the Japanese voiced fricative [z]. Again, greater glottal abduction was reported for the voiceless geminate fricative than for the non-geminate.

Nasal

In the only study of nasals, Kjellin (1977) has reported that for the Tibetan [m], as in [b], no glottal abduction was observed.

3.2. FIBEROPTIC STUDY OF MAITHILI

In the Maithili there is a four-way contrast involving aspiration and voice at bilabial, dental, retroflex and velar places of articulation, producing 16 stop consonants. There is also a four-way distinction in the manner of articulation of the affricate; traditionally affricates have been treated as palatal stops -- thus increasing the number of stops to 20. Phonetically there is also a two-way contrast between the aspirated and unaspirated varieties of bilabial, dental and velar nasal consonants, dental taps, and laterals. The inventory of Maithili aspirated and unaspirated pairs is shown in Table 3.I.

		CONSONANTS				
		Bilabial	*Dental*	*Retro-flex*	*Palatal*	*Velar*
Stops	unaspirated	p	t	ṭ		k
Voiceless	aspirated	p^h	t^h	$ṭ^h$		k^h
	unaspirated	b	d	ḍ		g
Voiced	aspirated	b^h	d^h	$ḍ^h$		g^h
Affricates	unaspirated				č	
Voiceless	aspirated				$č^h$	
	unaspirated				ǰ	
Voiced	aspirated				$ǰ^h$	
Nasals	unaspirated	m	n			ŋ
	aspirated	m^h	n^h			$ŋ^h$
Taps	unaspirated		r			
	aspirated		r^h			
Laterals	unaspirated		l			
	aspirated		l^h			

Table 3.I: Inventory of Maithili Aspirated and Unaspirated Pairs

Experimental Method

The author, a native speaker of Maithili, was the subject in this study. He was born in a village in the southeastern plains (known as the Tarai) of Nepal.

Data were obtained on two separate occasions using the facilities of Haskins Laboratories. The fiberoptic technique employed is as reported in Sawashima and Hirose (1968). Slow motion 16 mm. color films of the glottis were taken at a speed of 60 frames per second by inserting the fiberoptic bundle through the right nostril and positioning it level with the tip of the epiglottis in the hypopharynx. Before insertion of the fiberscope, the subject was given a surface anaestethic in the nasal cavity and the epipharynx. For the test utterances, Maithili words which contained the consonants to be examined were spoken in isolation. In the first experiment, these words were of the (C)VCV(...) type where V was always [i] and the intervocalic C was each of the ten dental series of stop, tap, lateral and nasal consonants (see Table 3.II). In the second experiment, Maithili words were used which contained the rest of the consonants differentiated by aspiration in both initial and final positions (see Table 3.III). These test utterances were recorded simultaneously on a magnetic tape in order accurately to identify and correlate each film frame to the corresponding wave form. In the first experiment, the utterances were repeated at least 10 times; in the second, these were repeated at least 5 times. The film for each of the consonant types was then analyzed frame-by-frame and measured in order to determine:

(i) the onset of glottal opening;
(ii) the width of the glottis for voiceless consonants;
(iii) the width of the posterior opening of the arytenoids (for voiced aspirated consonants); and
(iv) the closure of the glottis for normal voicing.

The width of the glottis was measured at the vocal processes. A few token were not sufficiently clear for measurement and have been omitted from the results reported below. The reference points for oral closure and its release were determined from the oscillographic wave forms with the help of a PDP-8 computer and by visual inspection.

3.3. RESULTS AND DISCUSSION

Results are shown in Tables 3.IV - 3.X and Figures 3.1 - 3.19. The tables give durational and glottal width information for all measurable medial and word-final tokens. Onset of glottal width is indicated at the first frame in which opening is observed; offset is indicated at the first frame in which complete closure is observed. Negative numbers indicate the number of frames prior to the release of oral closure at which this occurs and positive numbers the number of frames afater the release; zero indicates that it occurs at the point of oral release.

Maximum glottal width during oral closure and the following

[itir]	'this arrow'
[it^{h}ir]	'this patient (person)'
[ididi]	'this (elder) sister'
[id^{h}ia]	'this daughter'
[bini]	'knit'
[bin^{h}i]	'wasp sting'
[piri]	'elevated mass of clay (used for worship)'
[pir^{h}i]	'low stool'
[pili]	'(I) drank'
[pil^{h}i]	'jaundice'

Table 3.II: Test Utterances

segment is given on an arbitrary scale. For voiceless sounds, it is measured at the vocal processes. In voiced aspirated sounds, the vocal processes normally remain adducted, but an opening at the posterior end of the glottis is observed. Therefore, measurements of glottal width for voiced aspirated sounds represent the widest part of this posterior opening.

Oral closure duration was measured from the wave form and is given in milliseconds. Because the wave form was reproduced at approximately 2 inches per second, measurement error amy be as much as 15-20 msec.

The figures show temporal changes in the glottal width both for typical tokens and for averaged measurements. Time is represented by frames (60 per second) on the horizontal axis and glottal width is shown on an arbitrary scale on the vertical axis. R represents the point of oral release. Voiced unaspirated consonants are not shown in these figures when there is no glottal opening because lines drawn for them would be identical with the baseline.

3.3.1. Stops

3.3.1.1. Intervocalic stops [t, t^{h}, d, d^{h}]

Measurements for 8 tokens each of the intervocalic stops [t, t^{h}, d, d^{h}] are shown in Table 3.IV. Glottal width contours for typical tokens are given in Figure 3.1. and averaged measurements of the 8 tokens in Table 3.IV in Figure 3.2.

For [t], the vocal processes can first be observed to separate

[pəl]	'moment'	[bap]	'father'
[p^həl]	'fruit'	[b^hap^h]	'vapor'
[bəl]	'strength'	[ab]	'now'
[b^həl]	'good'	[lab^h]	'benefit'
[məl]	'rub'		
[ṭik]	'pigtail'	[həṭ]	'move'
[$ṭ^h$ik]	'true'	[həṭ^h]	'obstinacy'
[ḍik]	'huge pool of water'		
[$ḍ^h$il]	'louse'		
[ˇcor]	'thief'	[biˇc]	'center'
[$ˇc^h$or]	'leave'	[biˇc^h]	'pick up'
[ˇjor]	'strength'	[biˇj]	'seed'
[$ˇj^h$or]	'soup, curry'	[biˇj^h]	'rust'
[kam]	'work'	[bik]	'sell'
[k^ham^h]	'housepole'	[bik^h]	'poison'
[gam]	'village'	[bag]	'garden'
[g^ham]	'sweat'	[bag^h]	'tiger'
[g^hah]	'wound'		
[naŋ]	'naked'		
[naŋ^h]	'go across'		

Table 3.III: Test Utterances

about 7 frames before oral release whereas for [t^h] the separation is first observed 6 to 2 frames before release. This difference is probably related to the fact that oral closure duration is longer for [t] than for [t^h]. Voicing continues to linger for the initial 2 frames of the onset of oral closure for [t] and one frame for [t^h] after which no vibration of the vocal cords is observed during the remainder of the oral closure period.

For [t] the glottal opening is relatively narrow, and one or two frames after the oral release the vocal cords are adducted to vibrate for the following vowel. A well-defined bell-shaped contour characterizes the temporal course of glottal width for [t^h]. The glottis opens much wider than for [t], reaching its maximum

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Offset of Glottal Opening (in frames)
[t]	1	160	-7	8	2
	2	145	-7	7	1
	3	145	-6	8	2
	4	145	-7	6	2
	5	145	-7	8	1
	6	145	-7	8	1
	7	145	-5	6	2
	8	145	-8	6	1
[t^h]	1	100	-2	22	8
	2	100	-4	18	7
	3	100	-2	21	7
	4	100	-5	18	5
	5	100	-6	20	7
	6	100	-4	16	8
	7	100	-6	20	7
	8	100	-5	14	7
[d]	1	100	--	--	--
	2	100	--	--	--
	3	100	--	--	--
	4	100	--	--	--
	5	75	--	--	--
	6	100	--	--	--
	7	85	--	--	--
	8	100	--	--	--
[d^h]	1	100	-1	7	6
	2	100	-1	7	5
	3	85	-1	5	6
	4	100	-1	6	7
	5	100	0	4	4
	6	100	-1	7	6
	7	85	0	7	7
	8	75	0	6	6

* With reference to release of oral closure.
** Measured on an arbitrary scale.

Table 3.IV: Intervocalic [t, t^h, d, d^h]

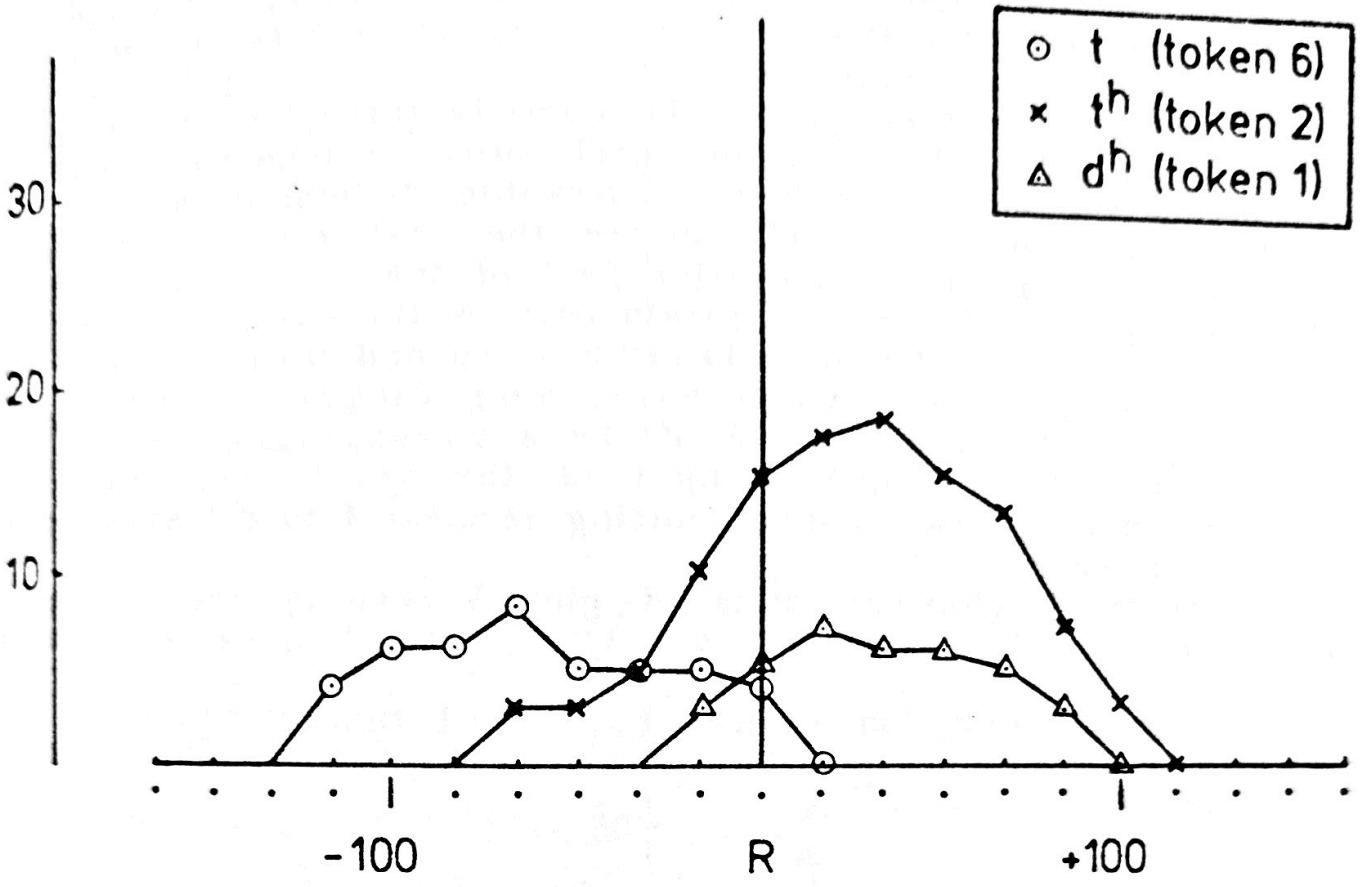

Fig.3.1: Typical glottal width contours for intervocalic [t, t^h, d^h]

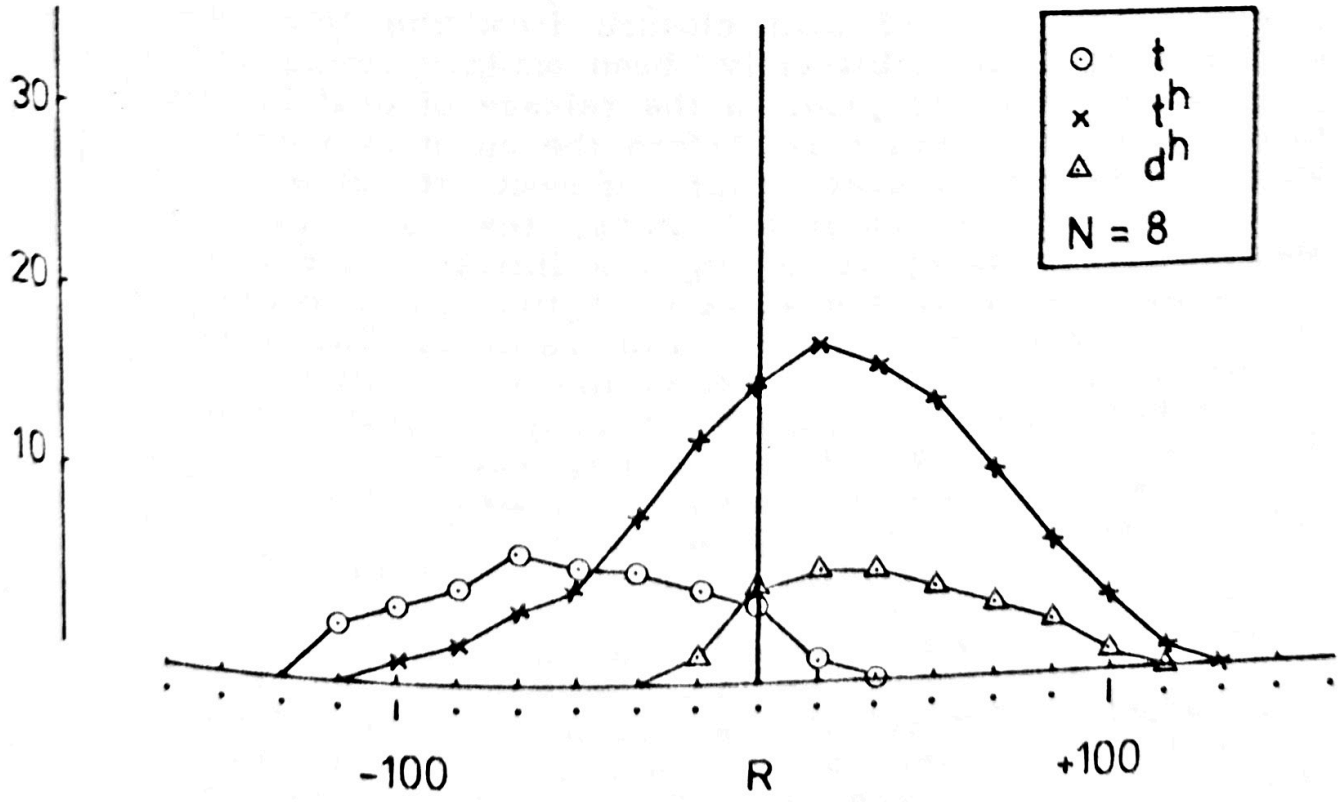

Fig.3.2: Average glottal width contours for intervocalic [t, t^h, d^h]

width immediately after the oral release. The vocal cords are adducted to vibrate for the following vowel about 7 frames after the release of the oral closure.

For [d] the vocal cords vibrate normally throughout the production of the stop. For [d^h], the vocal cords continue to be adducted during the closure with no observable difference in vibration until just at or immediately before the oral release, at which point an opening at the posterior part of the glottis is observed. The opening for the voiced aspirate reaches its maximum width one or two frames after the articulatory release and then a dark shadow envelopes the entire vocal cords, suggesting incomplete closure of the anterior portion. In 3 of the 8 tokens, a narrow slit extending almost the entire length of the vocal cords could be observed in one frame. Normal voicing resumes 4 to 6 frames after the oral release.

The temporal characteristics of glottal opening are similar to those reported by Hirose et al. (1972) and Kagaya and Hirose (1975).

Oral closure duration is longer for [t] than for [d]; on the average oral closure duration is also somewhat longer for [t^h] than for [d^h].

3.3.1.2. Initial Stops

The temporal change in glottal width is shown in Figures 3.3 - 3.5 for four tokens of the initial [p, p^h, b, b^h; ṭ, $ṭ^h$, ḍ, $ḍ^h$; k, k^h, g, g^h]. Since in initial position there is no way to determine the point of oral closure from the film or wave form, measurements have arbitrarily been made starting 10 frames (approximately 165 msec) prior to the release of oral closure. Measurements therefore always start before the onset of voicing for voiced stops and before the oral closure in most, if not all, stops.

For the voiceless aspirated stops, the vocal processes are observed to be wide apart during the initial phase of the utterance and remain so until the release of the oral closure, after which they immediately begin to narrow rapidly. The vocal cords are completely adducted for the following vowel after approximately 6 frames (i.e., 100 msec) for [p^h], and 4 frames (i.e., 66 msec) for both [$ṭ^h$] and [k^h] following the oral release.

For the voiceless unaspirated stops, too, the vocal processes begin fairly wide apart but narrow rapidly before the release of the oral closure. The vocal processes come into close contact for the following vowel immediately after the release of oral closure.

For both the voiced unaspirated and aspirated types, the complete contact of the vocal processes is observed during the oral closure period. For voiced unaspirated stops, adduction is achieved about 5 frames (i.e., around 80 msec.) prior to the oral release for [b] and [g], and about 7 frames (i.e., 155 msec.) prior to the release of the oral closure for [ḍ]. After this point no change

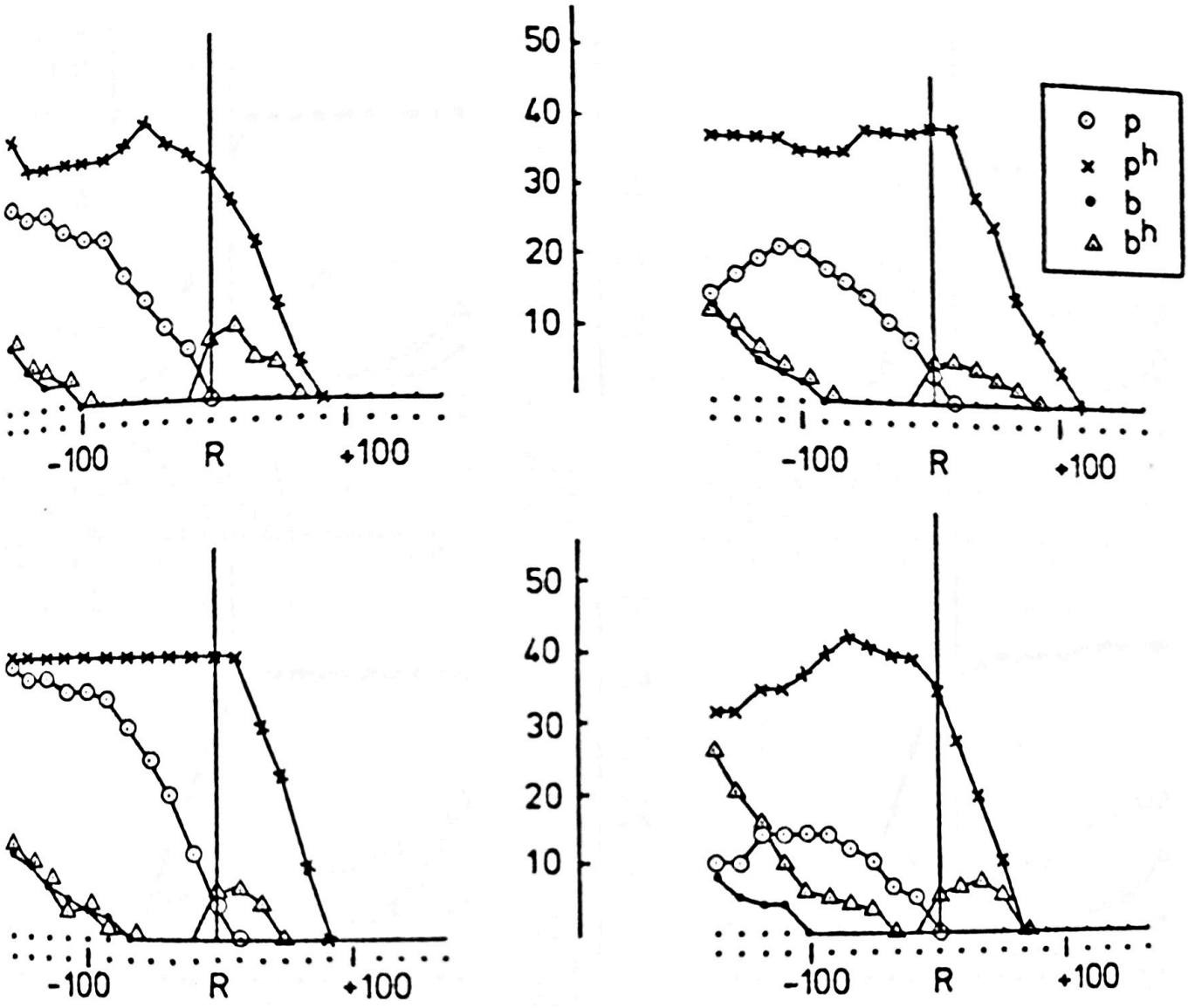

Fig.3.3: Glottal width contours for initial [p, p^h, b, b^h]

is observed in the glottal width during the production of voiced unaspirated stops.

For the voiced aspirated type, complete contact of the vocal processes is achieved at 4 - 5 frames prior to the oral release. At the oral release, a posterior opening of the arytenoids was observed in all the samples used in this study. Such a posterior opening lasted for about 3 frames (i.e., 50 msec.) after the articulatory release. Occasionally, a shadow covered the vocal cords and lasted for just one frame (2 out of 5 cases for the oral release of [b^h] and 1 out of 5 cases prior to the oral release of [g^h] and [b^h]).

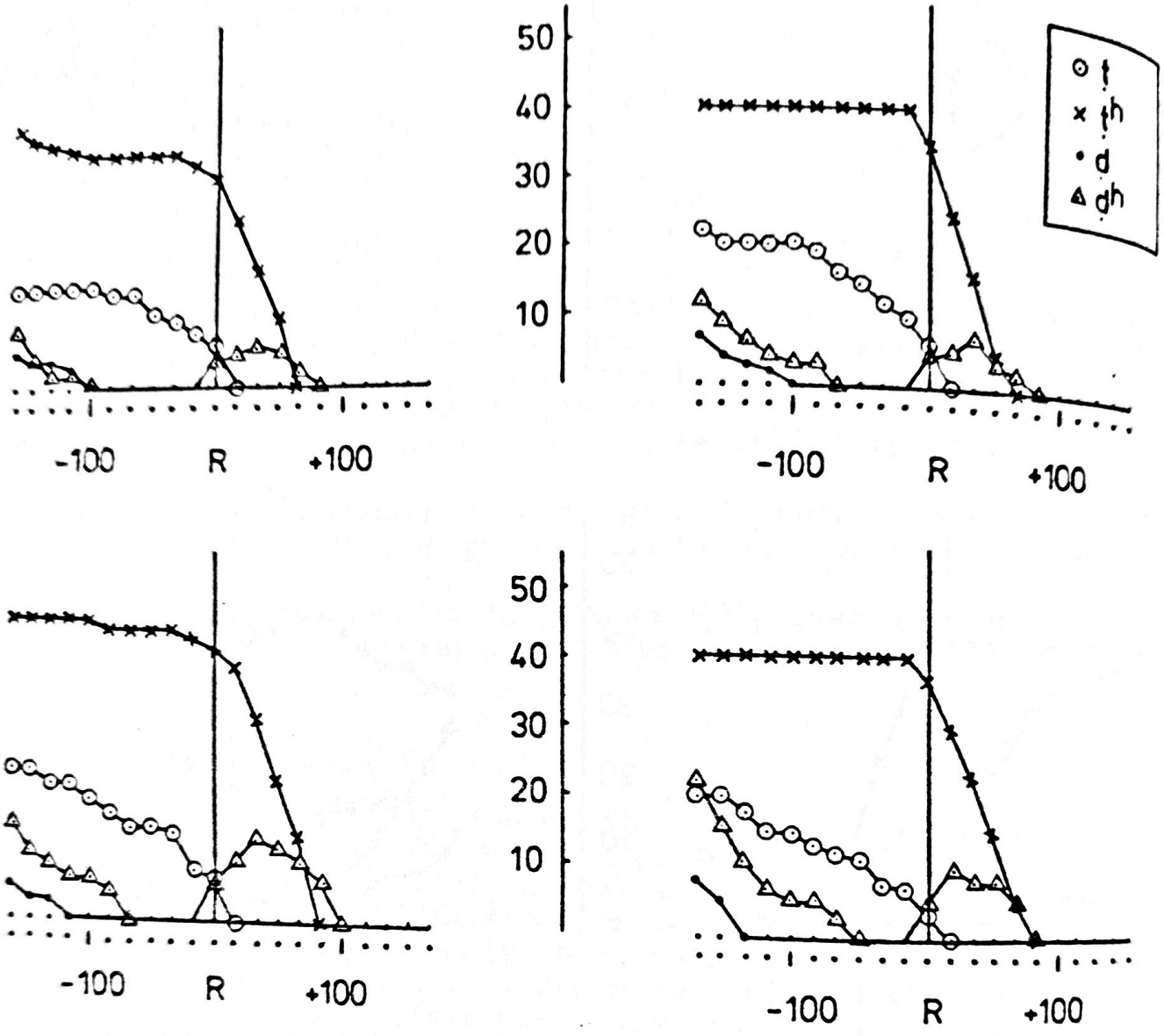

Fig.3.4: Glottal width contours for initial [ṭ, ṭʰ, ḍ, ḍʰ]

3.3.1.3. Final Stops

Tables 3.V - 3.VII show closure duration, onset of glottal opening, maximum glottal width, and the duration of the stop release for word-final consonants [p, pʰ, b, bʰ; ṭ, ṭʰ; k, kʰ, g, gʰ].

Figures 3.6 - 3.8 show typical glottal width contours for these same sounds. Because all the bilabial and the two voiced velar stops were preceded by the back vowel [a], the glottis was obscured by the epiglottis and it was not possible to determine the state of the glottis at the onset of oral closure in these instances. Measurements were taken from the first frame in which the glottis could be observed. It was always possible to observe the glottis at the onset of the oral closure for the final [k] and [kʰ],

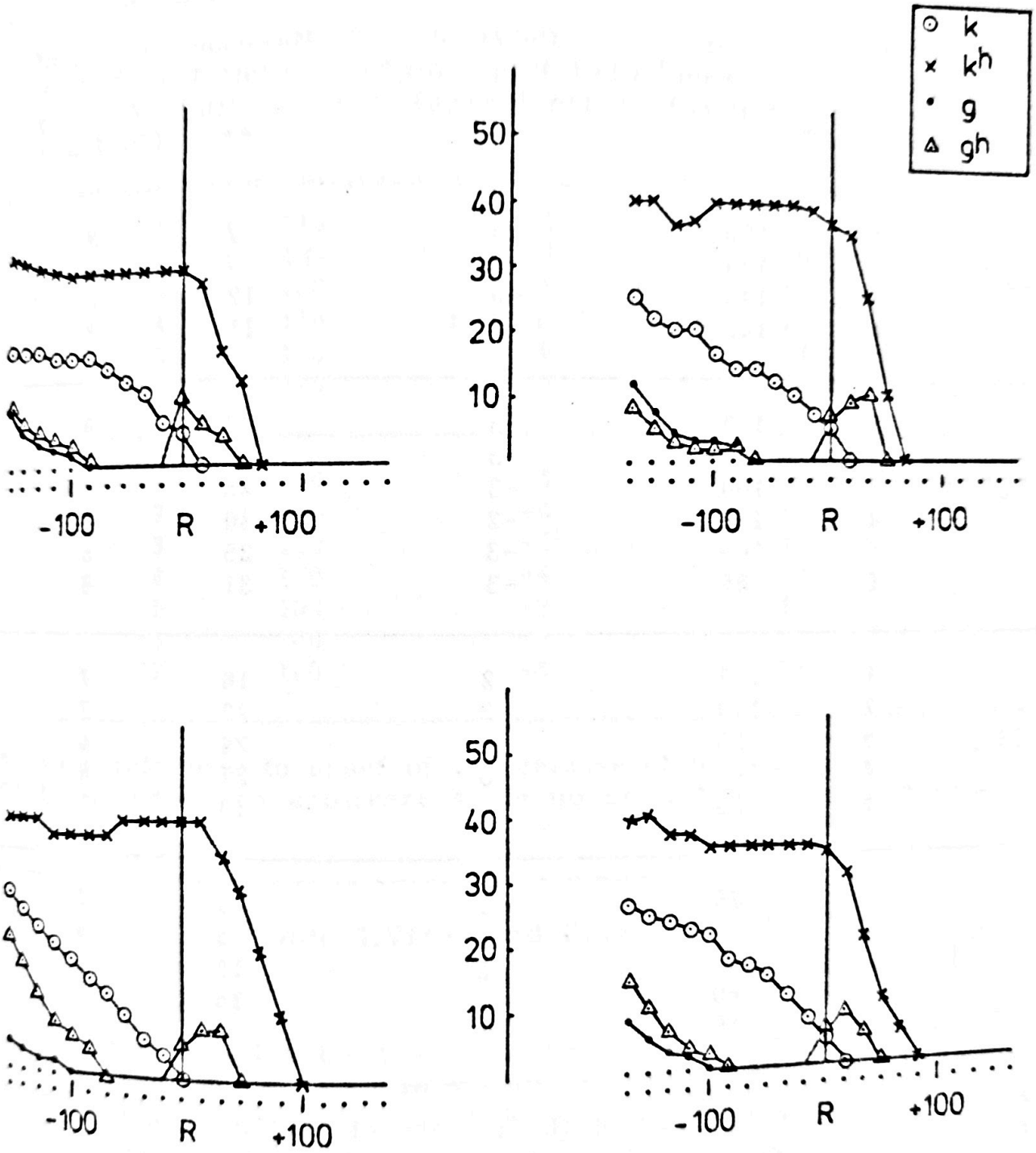

Fig.3.5: Glottal width contours for initial [k, k^h, g, g^h]

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Offset of Glottal Opening (in frames)
[p]	1	170	-5	7	3
	2	135	-3	7	4
	3	145	-5	12	4
	4	145	-6	11	3
[p^h]	1	100	-3	40	9
	2	100	-3	22	11
	3	100	-3	25	9
	4	100	-2	30	8
	5	100	-3	25	8
	6	85	-3	31	8
[b]	1	100	2	16	7
	2	100	3	22	7
	3	85	3	24	8
	4	100	3	27	8
	5	85	2	13	7
[b^h]	1	75	-1	20	7
	2	50	-1	25	9
	3	60	0	15	8
	4	60	-1	25	7
	5	50	0	22	7

* With reference to onset of the release of oral closure.
** Measured on an arbitrary scale up until the end of the stop release.

Table 3.V: Word Final [p, p^h, b, b^h]

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Duration of the Stop Release (in frames)
[ṭ]	1	145	-4	7	4
	2	135	-7	9	6
	3	100	-5	11	4
	4	110	not visible	10	3
	5	125	-6	8	5
	6	125	-6	9	4
[ṭ^{h}]	1	100	-4	30	7
	2	125	-6	40	6
	3	100	-5	37	6
	4	100	-4	40	6
	5	100	-3	30	7
	6	100	-5	34	7
	7	100	-5	28	6

* With reference to onset of the release of oral closure.
** Measured on an arbitrary scale up until the end of the stop release.

Table 3.VI: Word Final [ṭ, ṭ^{h}]

which were preceded by the front vowel [i]. For [k], the vocal cords were observed to be in vibration for 2 frames after the onset of the oral closure in 5 out of 6 instances; for [k^{h}] also the vibration of the vocal cords lingered for 2 to 3 frames after the onset of the oral closure. The state of the glottis during the onset of the oral closure for the retroflex stops [ṭ] and [ṭ^{h}], which were preceded by [ə], could also be observed in 12 out of 14 instances. For both [ṭ] and [ṭ^{h}] the vocal cords continued to vibrate until 2 frames after the onset of the oral closure.

For the voiceless unaspirated type, the vocal processes began to separate with a slightly open glottis on the average about 5 to 6 frames prior to the oral release for [ṭ] and 7 frames for [k]. The vocal processes remained separated throughout the sound. Following the release, the glottal width increased slightly for an average of 2 frames for [p], 3 frames for [ṭ] and 4 frames for

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Duration of the Stop Release (in frames)
[k]	1	145	-8	7	6
	2	125	-6	7	4
	3	125	-5	9	4
	4	125	-6	10	4
	5	125	-5	10	5
	6	135	-6	6	5
[k^h]	1	100	-4	39	9
	2	100	-4	42	9
	3	100	-4	45	9
	4	100	-4	40	9
	5	75	-4	39	9
	6	85	-4	40	10
[g]	1	75	1	15	6
	2	100	3	20	8
	3	100	1	15	5
	4	85	1	32	8
	5	100	3	23	7
	6	100	1	15	7
	7	100	2	11	5
[g^h]	1	75	-1	27	9
	2	75	0	20	11
	3	60	-1	18	10
	4	60	-1	12	13
	5	50	0	23	9
	6	60	-1	20	9

* With reference to onset of the release of oral closure.
** Measured on an arbitrary scale up until the end of the stop Release.

Table 3.VII: Word Final [k, k^h, g, g^h]

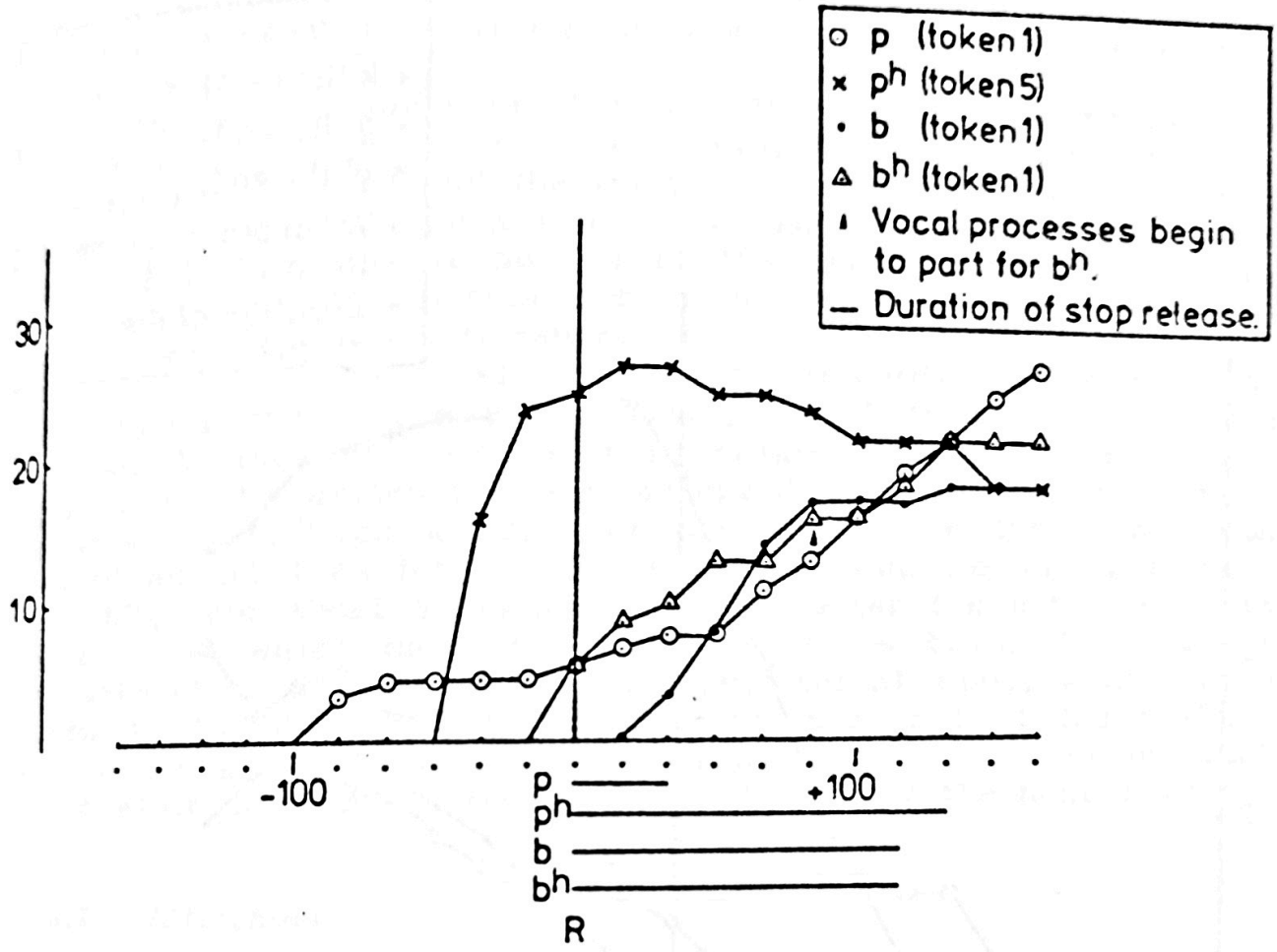

Fig.3.6: Typical glottal width contours for word final [p, p^h, b, b^h]

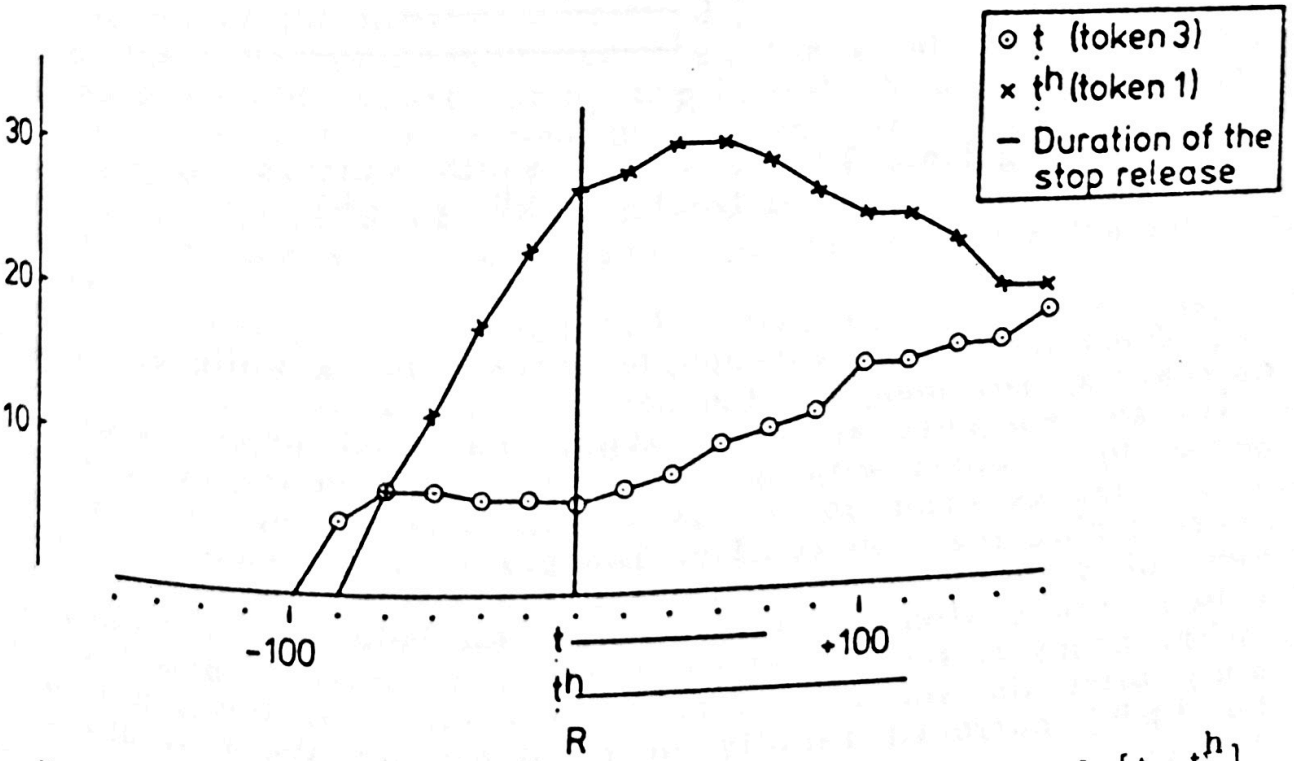

Fig.3.7: Typical glottal width contours for word final [t̪, $t̪^h$]

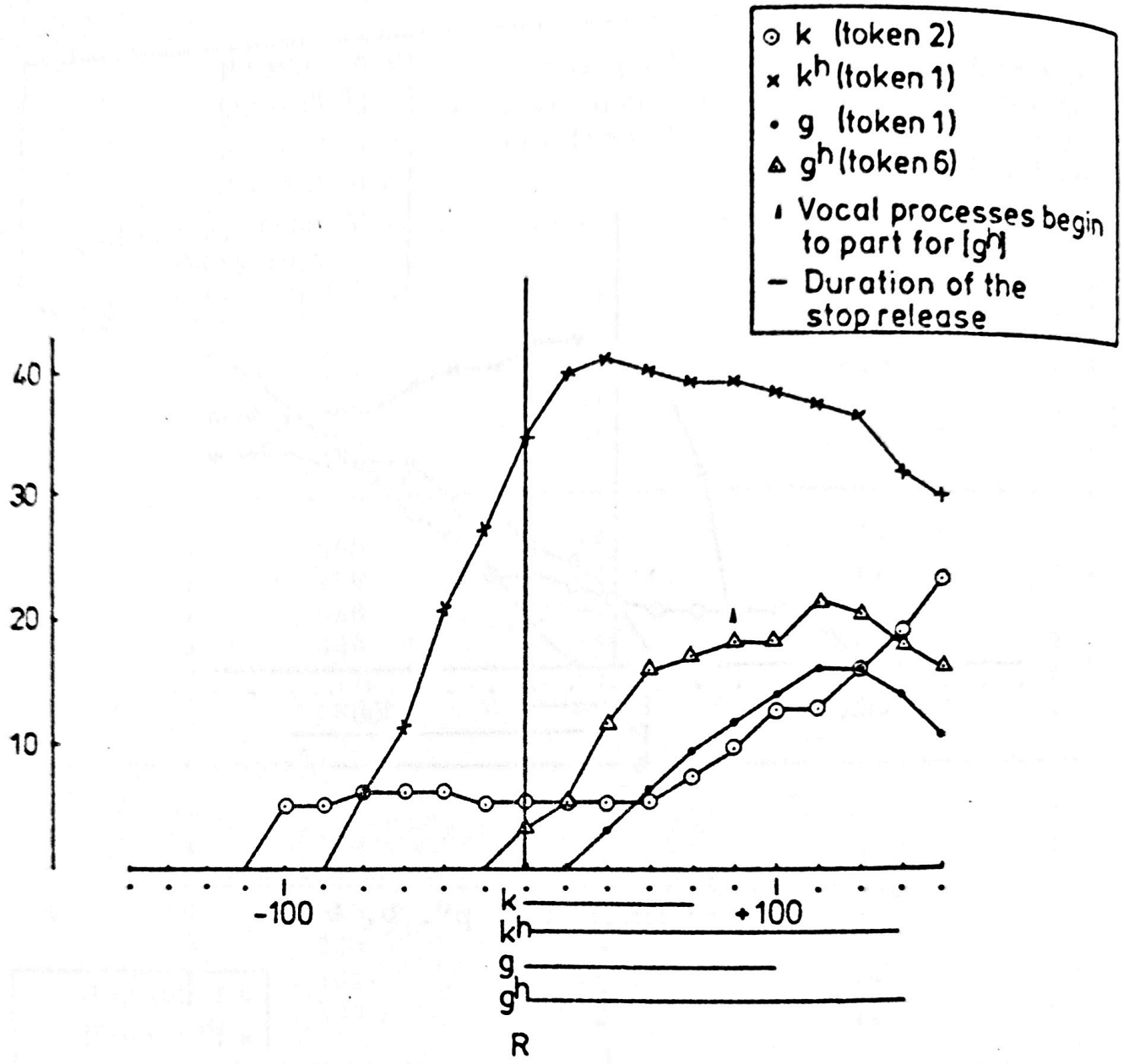

Fig.3.8: Typical glottal width contours for word final [k, k^h, g, g^h]

[k]. Then the glottis widened for breath for a while and finally narrowed in readiness for the next utterance.

For the voiceless aspirated type, the vocal processes were observed to be apart with a wide open glottis on the average about 4 - 5 frames prior to the stop release and they remained wide apart during the stop release. The glottal width increased immediately after the onset of the release and reached its maximum about 2 to 3 frames after the release onset for both [t^h] and [k^h]. For [p^h], however, the glottal width began to decrease almost immediately after the release onset. In one instance, the glottal width for [p^h] narrowed rapidly in readiness for the nest utterance. The glottis was much wider for the voiceless aspirated type than

for the voiceless unaspirated type both during the oral closure and the release period. It was also wider than the glottal opening between words.

For the voiced unaspirated stops, the vocal processes were observed to be in close contact with vibrating vocal cords both during the oral closure and the release period. The vocal processes, however, began to separate about 2 frames following the release onset so that the final portion of the release was devoiced. The glottis widened for breath for a while and then narrowed in readiness for the next utterance.

For the voiced aspirated type, the vocal cords were in vibration both during the oral closure (lasting 4 - 5 frames) and the oral release. At the oral release or immediately before it, a posterior opening of the arytenoids was observed in all the samples used in this study. Such a posterior opening, while the anterior remained adducted as for regular voice, lasted for about 2 frames for [b^h] and about 5 frames for [g^h] after the articulatory release -- at which point the vocal processes began to part. For the sake of comparison with initial and medial stops, glottal width given in the tables and figures was measured at the posterior end of the glottis. The glottis remained open in a state of breath for a while and then narrowed in readiness for the next utterance.

3.3.2. Affricates

3.3.2.1. Initial

The temporal change in glottal width is shown in Figure 3.9 for four tokens of the initial [$\check{c}$, $\check{c}^h$, $\check{j}$, $\check{j}^h$].

For the voiceless unaspirated [$\check{c}$], the vocal processes were observed to be wide apart during the initial phase of the utterance, but they gradually narrowed during and after the oral closure. The articulatory release of [$\check{c}$] coincided with the onset of the frication, which lasted about 2 frames after the release -- at which point the vocal cords adducted for voice for the following vowel.

For the voiceless aspirated [$\check{c}^h$], too, the vocal processes were observed to be wide apart during the initial phase of the utterance, but they remained wide apart throughout the oral closure. At the release of [$\check{c}^h$] and the onset of frication, which lasted on the average about 2 frames, the glottis began to narrow. Complete closure was not observed until around 5 frames after the cessation of frication. It should be noted, however, that from the oscillographic wave form, it was not always possible to determine exactly the boundary between the cessation of the frication and the onset of the aspiration. However, the vocal cords were fully adducted for the following vowel 6 - 7 frames after the closure release.

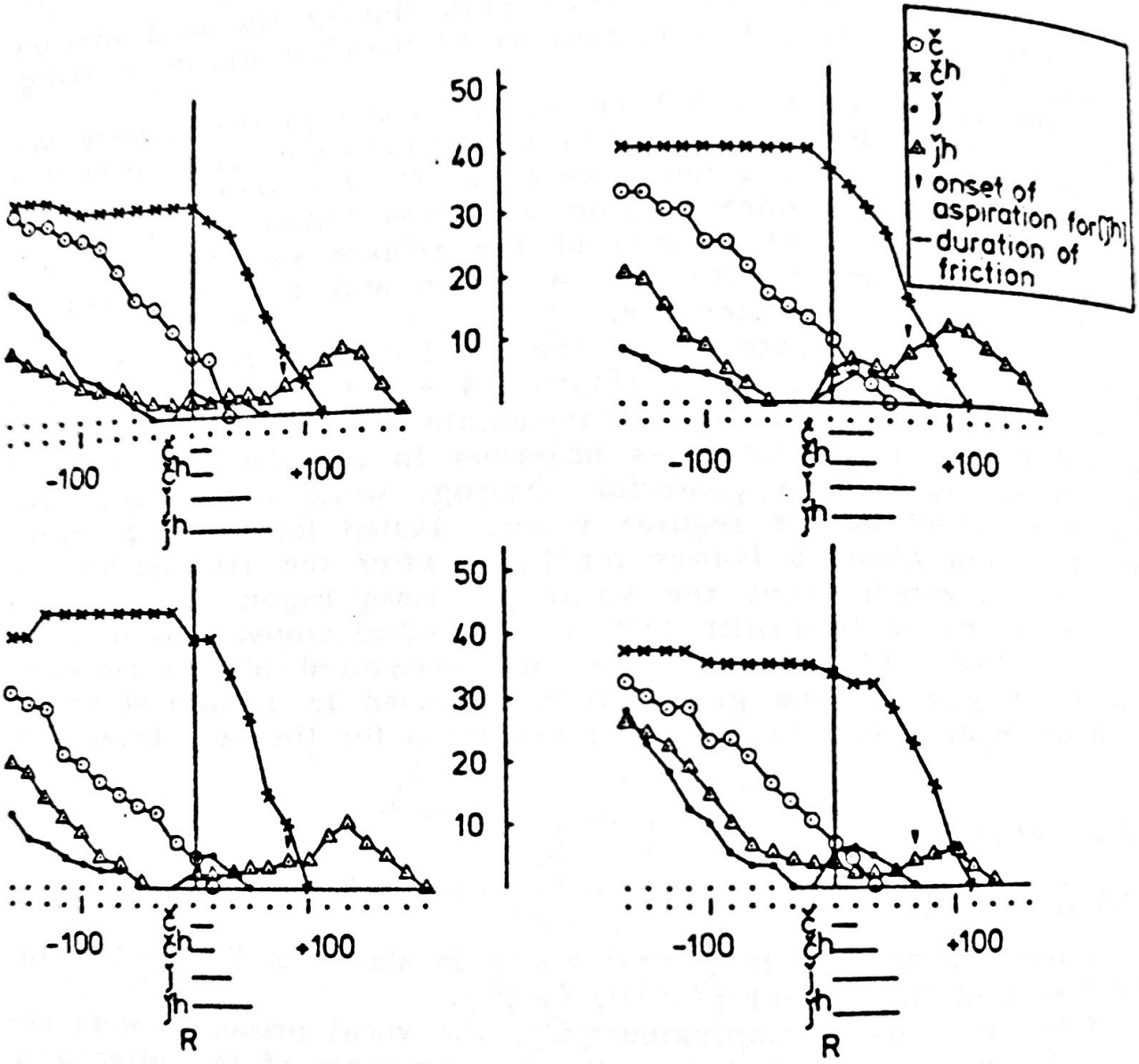

Fig.3.9: Glottal width contours for initial [č, čh, j, jh]

For the voiced unaspirated [j], the vocal cords were observed to be in vibration for regular voice for 2 to 3 frames prior to the release of the oral closure. However, during the frication, the vocal processes were observed to part slightly. The frication lasted about 4 frames, and then the vocal cords adducted for normal voice for the following vowel.

For the voiced aspirated [jh], the vocal cords were observed to be in vibration at the point of oral release. However, during this period of vibration, the vocal processes did not seem to be in close contact. Such a gesture of incomplete contact of the vocal processes lasted for 4 to 5 frames. At this point, in all the samples used in this study, a posterior opening of the arytenoids appeared while the anterior remained adducted. The period of pos-

terior opening lasted around 6 to 7 frames, and then a normal voicing gesture with close contact of the vocal processes and no posterior opening began.

3.3.2.2. Final

Table 3.VIII shows closure duration, onset of glottal opening, maximum glottal width, and the duration of the segment following release for the word-final affricates [č, čʰ, ǰ, ǰʰ].

Figure 3.10 shows typical glottal width contours for the same word-final consonants.

For the voiceless unaspirated [č], the vocal processes were observed to separate about 4 frames prior to the oral release, and the glottal width reached its maximum around 3 frames after the onset of the oral closure. However, in 5 cases out of 6, the vocal processes were not observed to be apart in the first frame at the onset of the oral closure. For [č], the onset of the frication is also the point of oral release. From the oscillographic wave form it was not possible to distinguish frication from aspiration; hence the total duration of the frication plus aspiration was measured. After the release, the glottal width decreased and then again increased for the breath gesture. No vibration of the vocal cords was observed during the closure or release period.

For the voiceless aspirated [čʰ], the vocal processes were not observed to separate in the first frame after the onset of the oral closure. Instead they began to separate around 3 to 4 frames prior to the release of the oral closure. The frication lasted about 2 to 3 frames. As far as it was possible to determine, the aspiration began 2 to 3 frames after the oral release. The glottal width increased during this period and reached its maximum around 2 frames after the onset of the aspiration.

For the voiced unaspirated [ǰ], the vocal cords were observed to be in vibration both during the oral closure and the release of the oral closure. However, during the release, the vocal processes were observed not to be in close contact. Such vibration with incomplete contact of the vocal processes, accompanying frication, lasted on the average about 4 frames -- after which the glottal width increased for breath.

For the voiced aspirated [ǰʰ], too, the vocal cords were in vibration both during the oral closure and the release of the oral closure. Here, too, the vocal processes were not in close contact during the release. The gesture, accompanying frication, lasted about 2 to 3 frames. After the cessation of the frication, a posterior opening of the arytenoids, while the anterior continued to be adducted, was observed in all the samples used in this study. This opening lasted about 3 to 4 frames after which the vocal cords opened for breath. For the sake of comparison, glottal width was measured at the posterior end of the glottis as in other voiced aspirated consonants.

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Duration of The Segment Following Onset of Release (in frames)
[ɤ̆]	1	75	-3	12	6
	2	100	-5	9	5
	3	100	-4	13	8
	4	75	-3	8	6
	5	85	-4	10	6
	6	100	-5	12	7
[ɤ̆^{h}]	1	75	-4	37	12
	2	50	-2	40	12
	3	75	-4	42	9
	4	75	-4	39	9
	5	75	-3	33	10
	6	85	-4	36	10
[j̆]	1	50	2	15	8
	2	50	3	15	10
	3	75	3	10	6
	4	50	5	21	10
	5	75	5	14	10
	6	50	7	10	10
[j̆^{h}]	1	50	0	17	10
	2	40	2	22	11
	3	40	3	17	9
	4	40	2	25	10
	5	40	0	25	9
	6	50	0	22	10

* With reference to onset of the release of oral closure.
** Measured on an arbitrary scale up until the end of the segment following onset of release.

Table 3.VIII: Word Final [ɤ̆, ɤ̆^{h}, j̆, j̆^{h}]

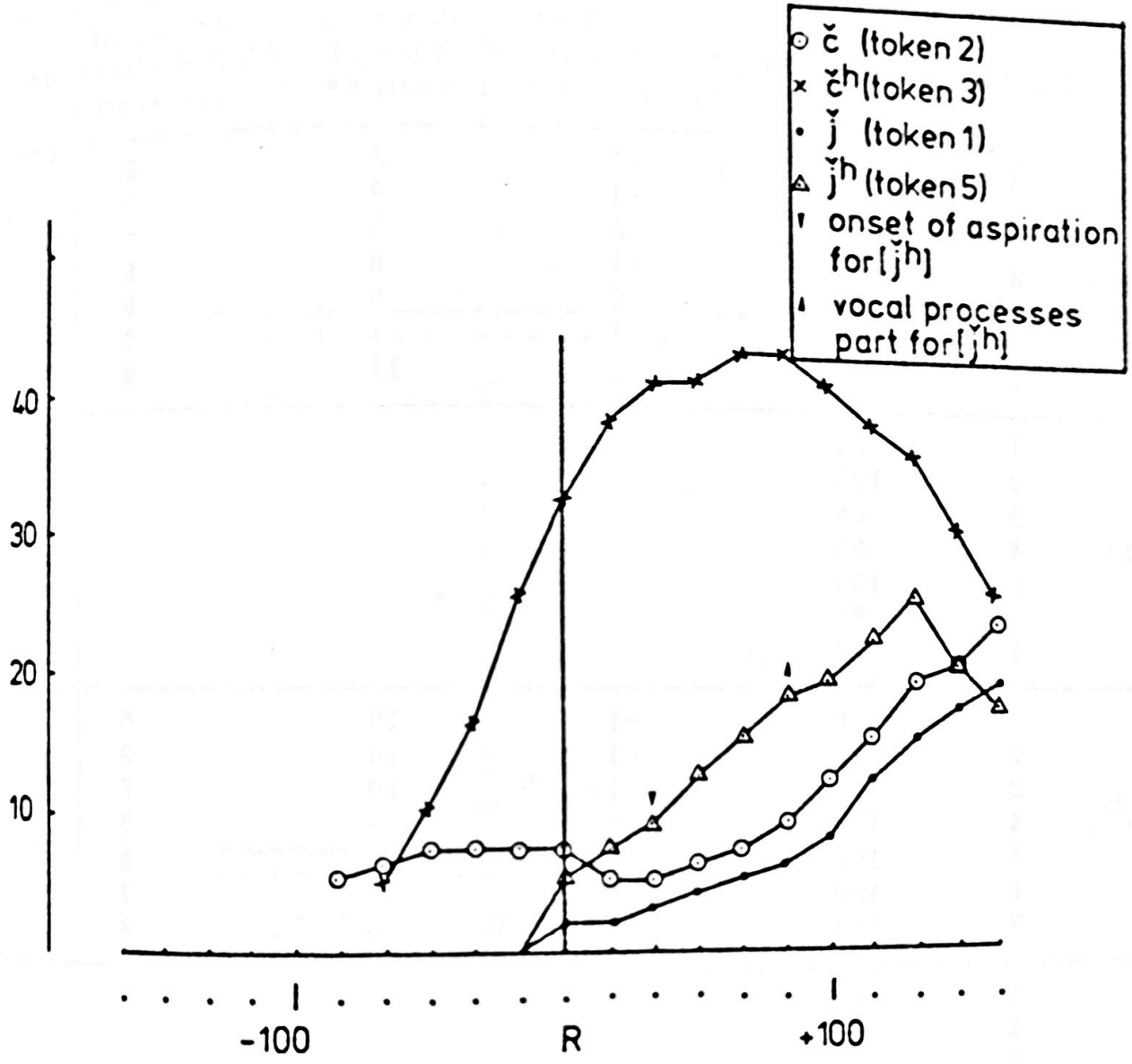

Fig.3.10: Typical glottal width contours for word-final [č, čʰ, ǰ, ǰʰ]

3.3.3. Other Consonants

3.3.3.1. Intervocalic [r, rʰ, l, lʰ, n, nʰ]

Table 3.IX shows closure duration, onset and offset of glottal opening, and maximum glottal width for intervocalic [rʰ, l, lʰ; n, nʰ].

Figure 3.11 shows typical glottal width contours (measured at the posterior opening of the arytenoids) for the same consonants. No contours for the unaspirated [r, l, n] have been shown because the lines representing their glottal width would be identical with the zero baseline. For the production of [r, l, n], the vocal processes were observed to be in complete contact, and the

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width**	Offset of Glottal Opening* (in frames)
[r^h]	1		-1	8	8
	2		-1	9	8
	3		0	8	5
	4		-1	8	6
	5		-1	8	9
	6		-1	7	8
	7		-1	11	8
[l]	1	85			
	2	100			
	3	85			
	4	85			
	5	100			
	6	85			
	7	100			
[l^h]	1	100	-1	10	6
	2	75	-1	10	9
	3	100	-1	10	6
	4	100	-1	10	7
	5	100	-1	10	8
	6	100	-1	12	7
	7	100	-1	9	6
[n]	1	85			
	2	100			
	3	85			
	4	85			
	5	100			
	6	85			
	7	100			
[n^h]	1	75	-1	10	5
	2	100	-1	9	7
	3	85	-1	7	4
	4	75	0	6	7
	5	100	-1	10	7
	6	75	-1	10	8
	7	75	-1	9	7

* With reference to tap for [r^h] and with reference to release of closure for [l^h] and [n^h].

** Measured on an arbitrary scale.

Table 3.IX: Intervocalic [r^h, l, l^h; n, n^h]

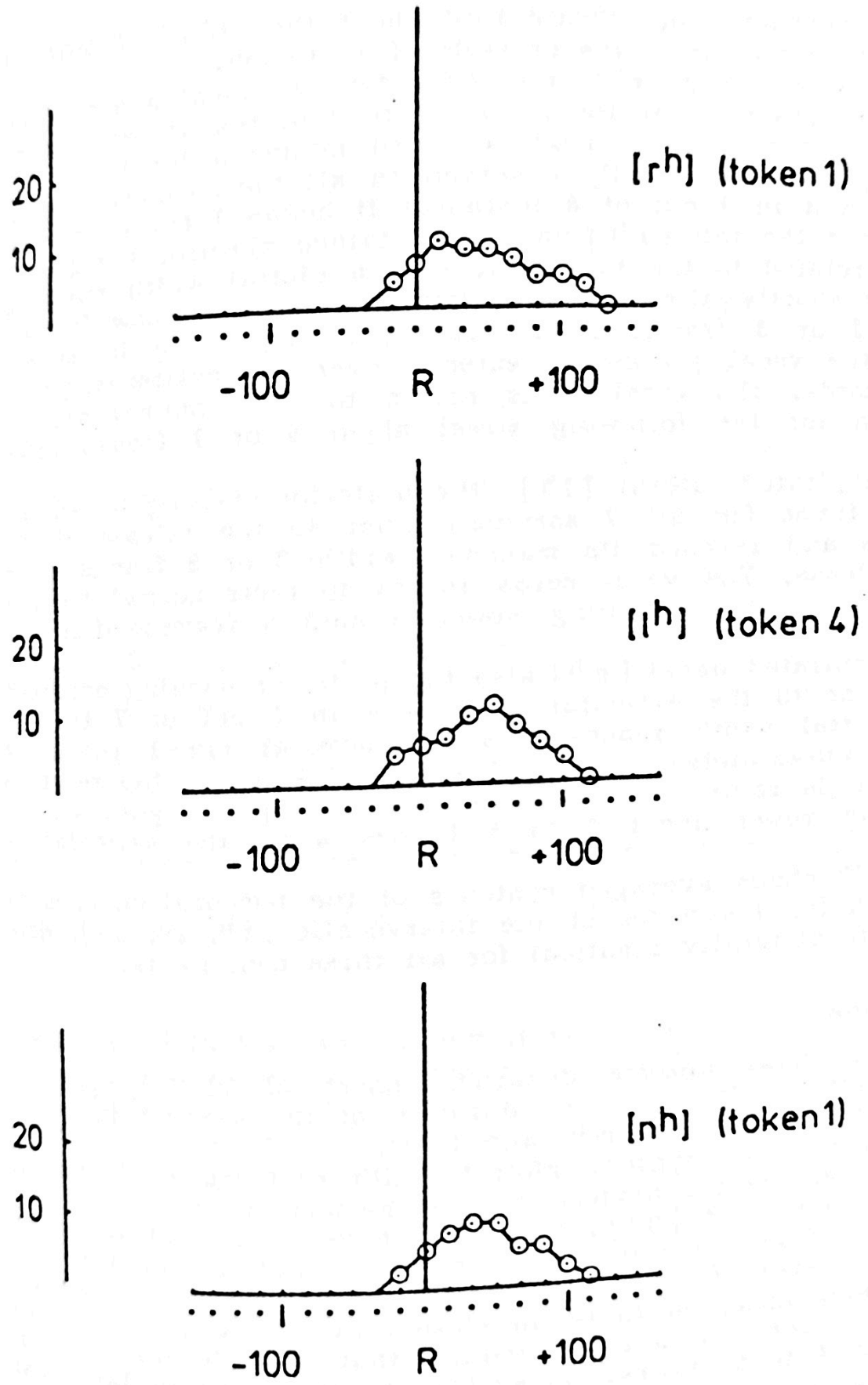

Fig.3.11: Typical glottal width contours for intervocalic [r^h, l^h, n^h].

vocal cords continued to vibrate throughout the utterance with no observable difference in shape or mode of vibration.

For the aspirated tap [r^h], the characteristic opening for voiced aspirates was observed at the posterior part of the arytenoid cartilages, while the anterior part remained adducted for vibration. This opening was consistently observed in all the samples used in this study, and in 7 out of 8 instances it began 1 frame prior to the tap. Since the tap [r^h] has no sustained closure, the glottal opening is related to the tap itself -- the glottal width reaching its maximum shortly after the tap. Occasionally a shadow (usually around 2 or 3 frames after the tap), suggesting incomplete closure of the vocal processes, extends over the entire length of the vocal cords. The vocal cords return to their normal voicing configuration for the following vowel about 6 or 7 frames after the tap.

For the aspirated lateral [l^h], the posterior opening began invariably 1 frame (in all 7 samples) prior to the release of the oral closure and reached its maximum width 2 or 3 frames after the oral release. The vocal cords return to their normal voicing configuration for the following vowel around 5 frames after the release.

For the aspirated nasal [n^h] also the posterior opening occurred 1 frame prior to the articulatory release in 5 out of 7 tokens, and the glottal width reached its maximum at (in 1 out of 7 tokens), or immediately after (in 6 out of 7 tokens), the release. The vocal cords returned to their normal voicing configuration for the following vowel about 4 to 5 frames after the articulatory release.

Figure 3.12 shows averaged contours of the temporal changes in glottal width for 7 samples of the intervocalic [r^h, l^h, n^h]. Note that they are virtuallly identical for all three consonants.

3.3.3.2. Final

Table 3.X shows closure duration, onset of glottal opening, maximum glottal width, and the duration of the segment following release for the word-final [m^h] and [$ŋ^h$].

Figure 3.13 shows typical glottal width contours (measured at the posterior end of the arytenoids) for the same consonants.

For both [m^h] and [$ŋ^h$], the view of the glottis at the onset of oral closure and a few frames thereafter was obscured by the epiglottis. However, from the time the vocal processes became visible, they were observed to be in close contact. From the oscillographic wave form it was determined that the closure duration lasted about 4 to 5 frames. No systematic difference in laryngeal dynamics was observed during the closure period for the segment. At the release, or one frame prior to the release, an opening of the posterior end of the arytenoids occurred while the anterior remained adducted. Such a posterior opening was found in all the

	Tokens	Closure Duration (in msec)	Onset of Glottal Opening* (in frames)	Maximum Glottal Width **	Duration of the Segment Following the Onset of Release (in frames)
[m^h]	1	60	-1	23	9
	2	75	0	12	10
	3	75	0	22	9
	4	100	0	10	10
	5	100	0	20	9
	6	75	0	17	9
[$ŋ^h$]	1	125	0	20	7
	2	100	0	18	10
	3	110	0	15	10
	4	100	0	15	9
	5	125	0	10	10

* With reference to release of closure.
** Measured on an arbitrary scale up until the end of the segment following the onset of release.

Table 3.X: Word Final [m^h, $ŋ^h$]

samples used in this study, and it lasted on the average of about 2 to 3 frames after the release -- at which point the vocal processes started to abduct.

Figure 3.14 shows averaged contours of the temporal changes in the glottal width for 5 samples of the word-final [m, $ŋ^h$].

In sum, the resonants [r^h, l^h, n^h, m^h, $ŋ^h$], like other voiced aspirated consonants, are characterized by a consistent posterior opening of the arytenoids and occasional narrow slit throughout and/or shadowing of the entire length of the vocal cords (see Figures 3.15 and 3.16).

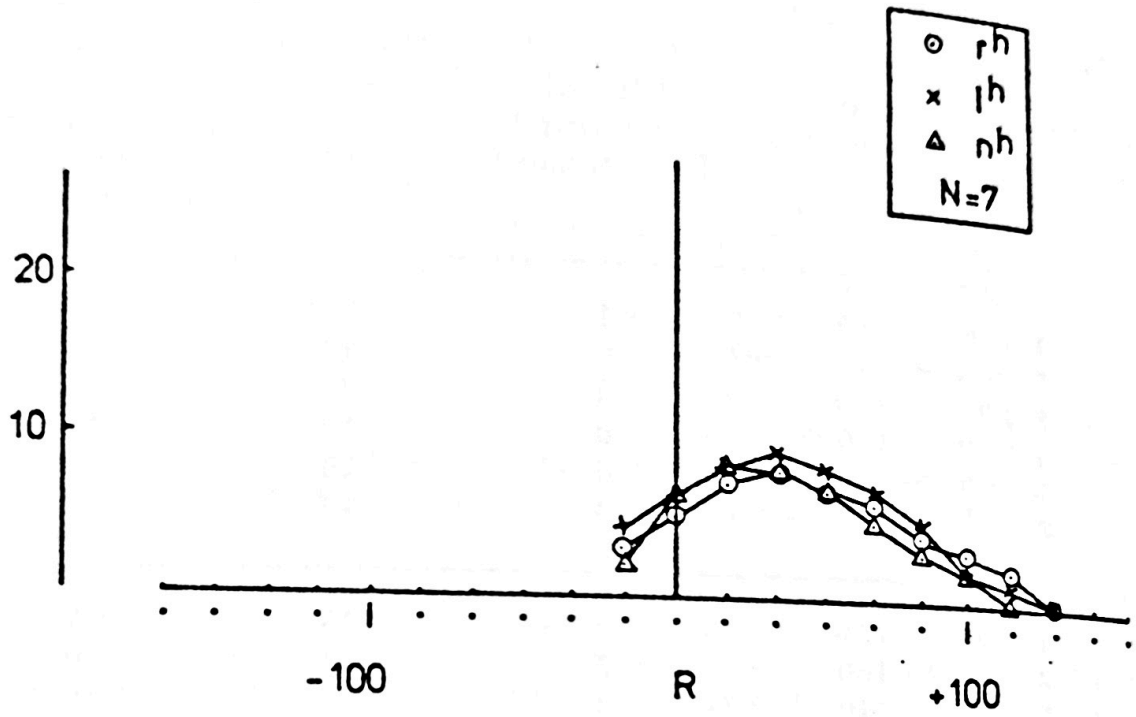

Fig.3.12: Average glottal width contours for intervocalic [rʰ, lʰ, nʰ].

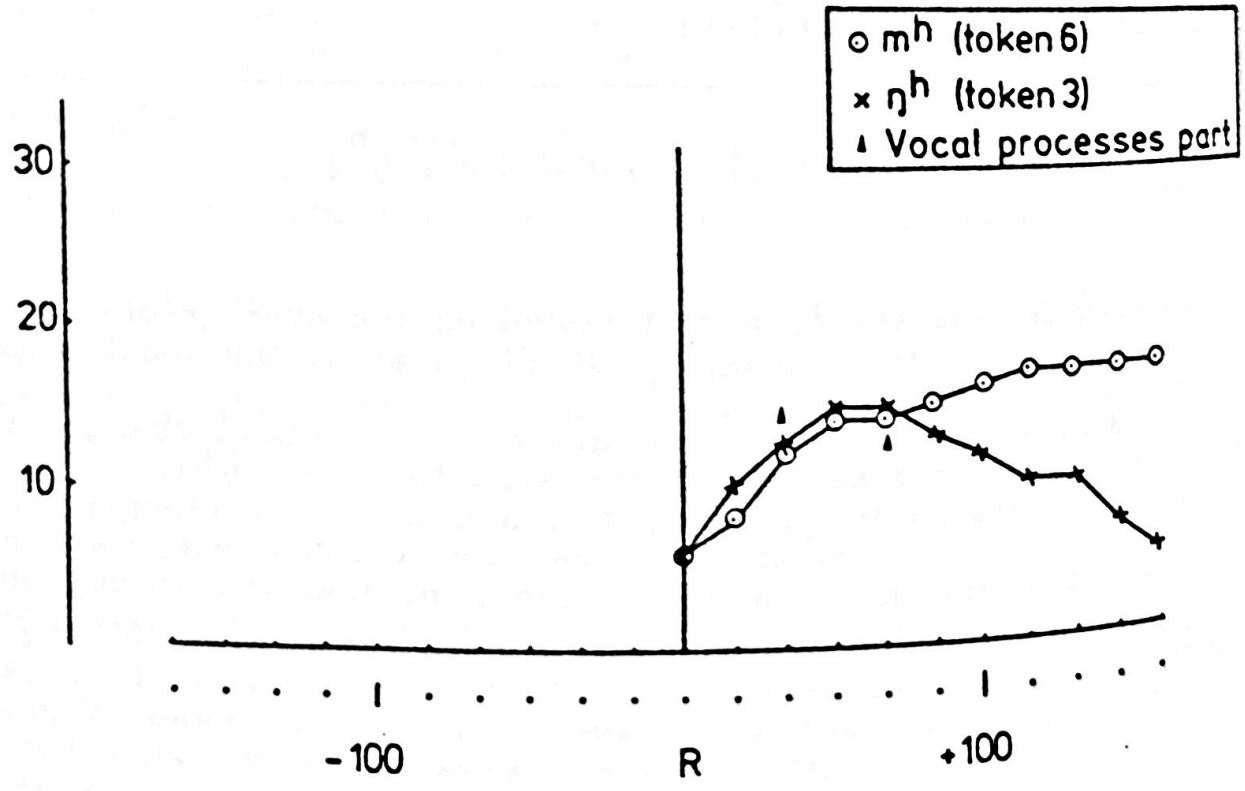

Fig.3.13: Typical glottal width contours for word-final [mʰ, ŋʰ].

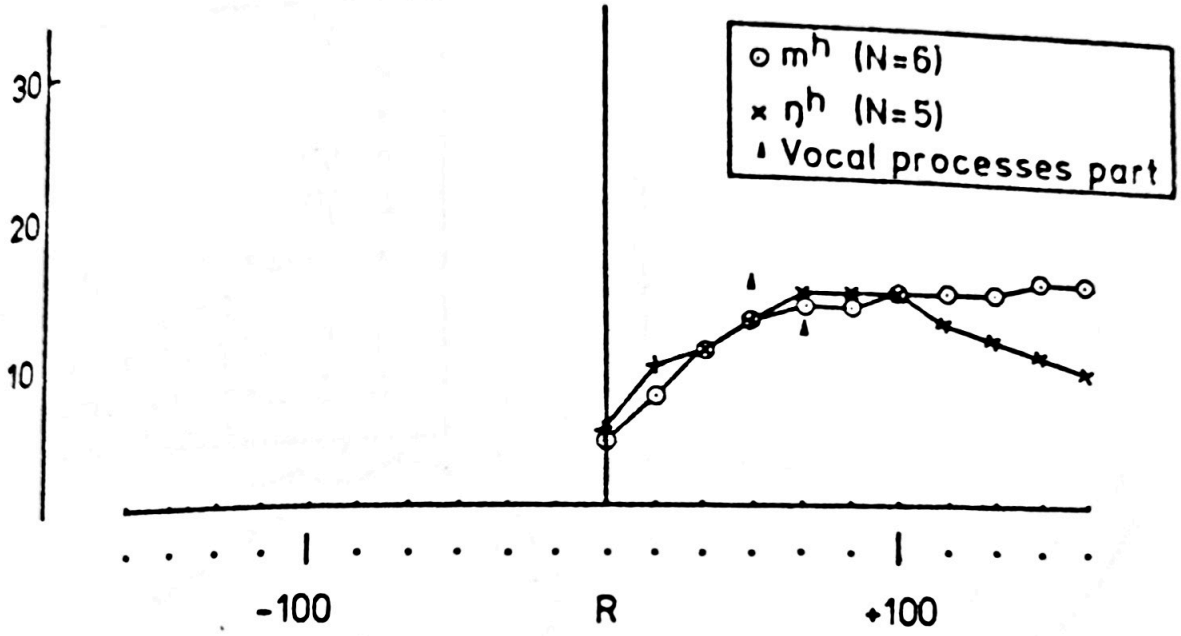

Fig.3.14: Average glottal width contours for word-final [m^h, $ŋ^h$].

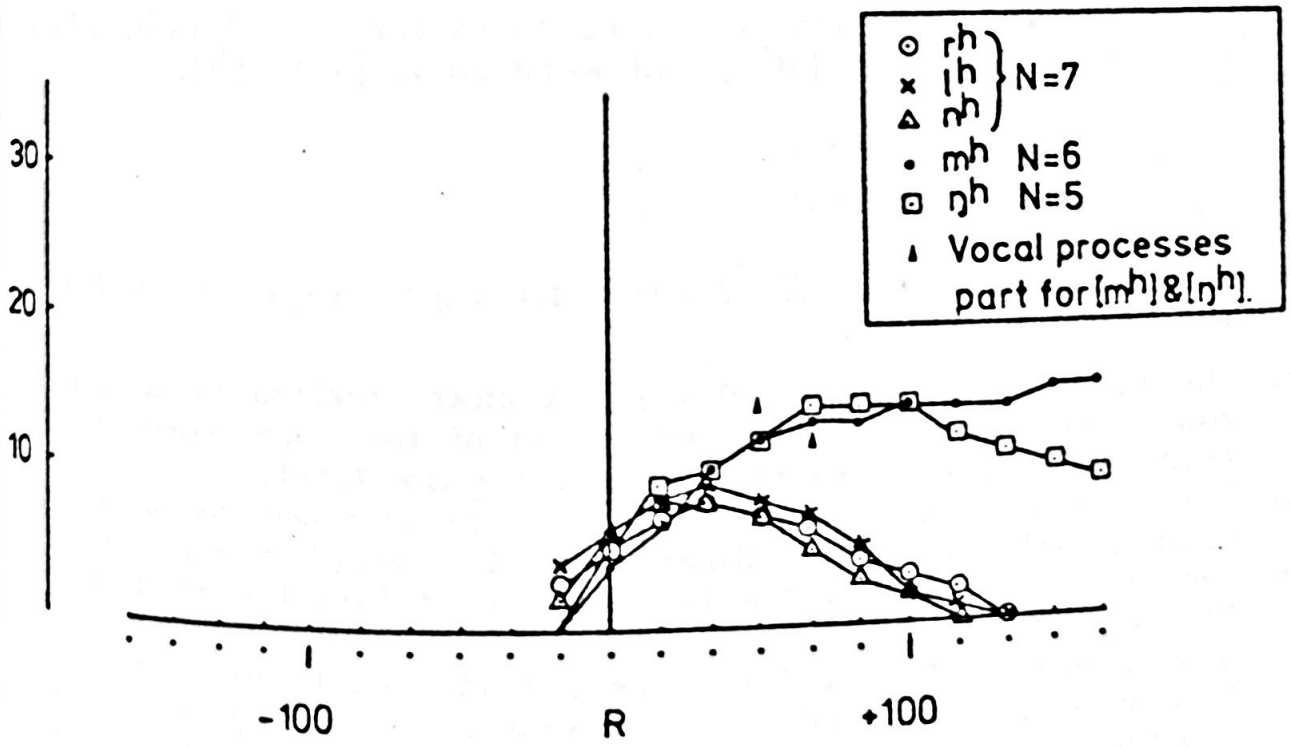

Fig.3.15: Average glottal width contours for intervocalic [r^h, l^h, n^h] and word-final [m^h, $ŋ^h$].

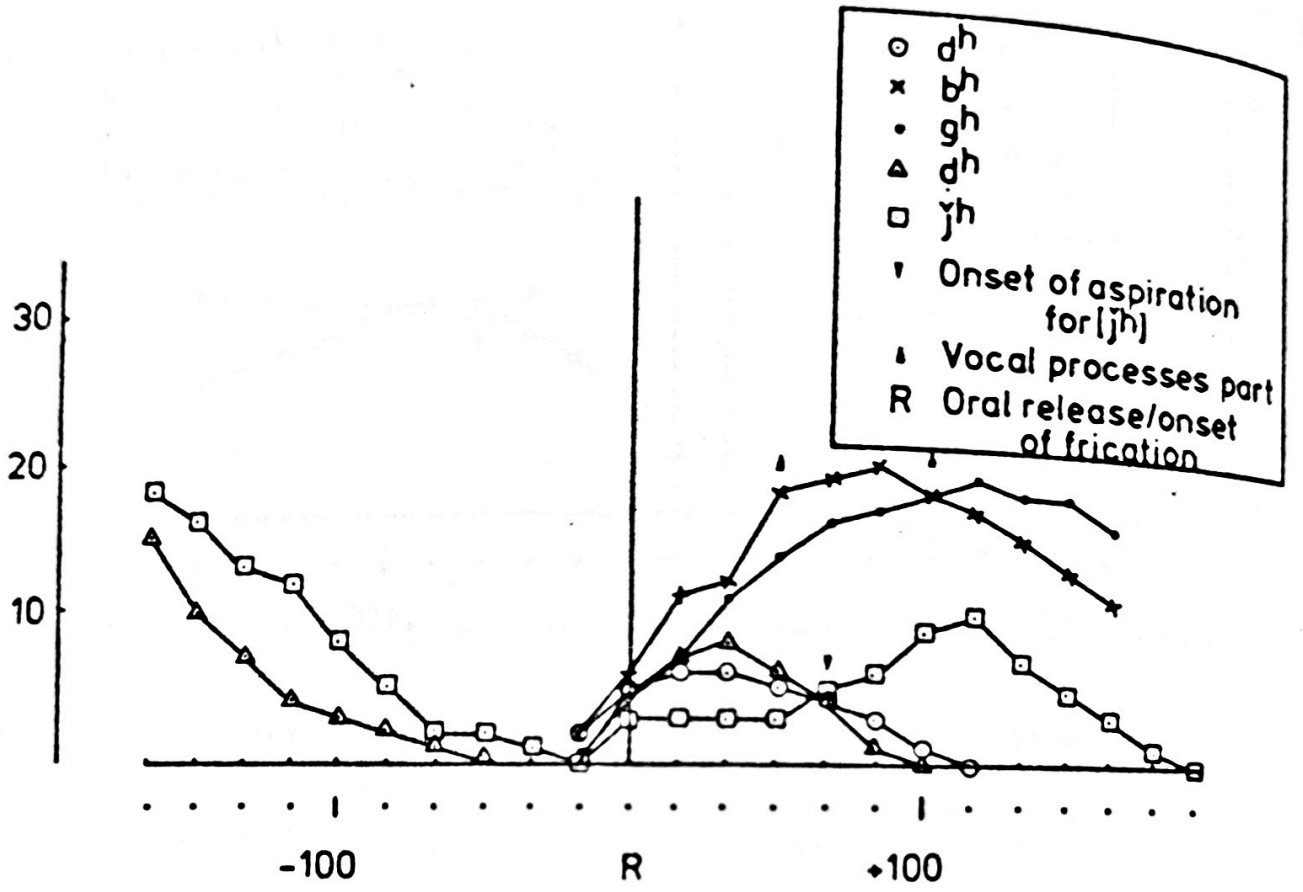

Fig.3.16: Average glottal width contours for initial [d̤^{h}, j̈^{h}], intervocalic [d^{h}] and word-final [b^{h}, g^{h}].

3.4. SUMMARY

Examination of the results of these fiberoptic experiments reveals the following:

1. The voiceless unaspirated type is characterized by a narrow open glottis with no vibration of the vocal cords during the oral closure period (see Figure 3.17).
2. The voiceless aspirated type is characterized by a wide open glottis with no vibration of the vocal cords during the oral closure and the release period (see Figure 3.18).
3. The voiced unaspirated type is characterized by a closed glottis during the oral closure period (see Figure 3.19).
4. The voiced aspirated type is characterized by a closed glottis during the oral closure period and a posterior opening of the arytenoids at or immediately before the articulatory release. Voicing is observed to be present throughout, including the time when there is a posterior opening (see Figures 3.15 and 3.16).
5. The present study suggests that glottal width is the key factor for aspiration. A modification of the definition of aspiration as glottal width will enable us once again to include both types of aspiration in the same phonetic

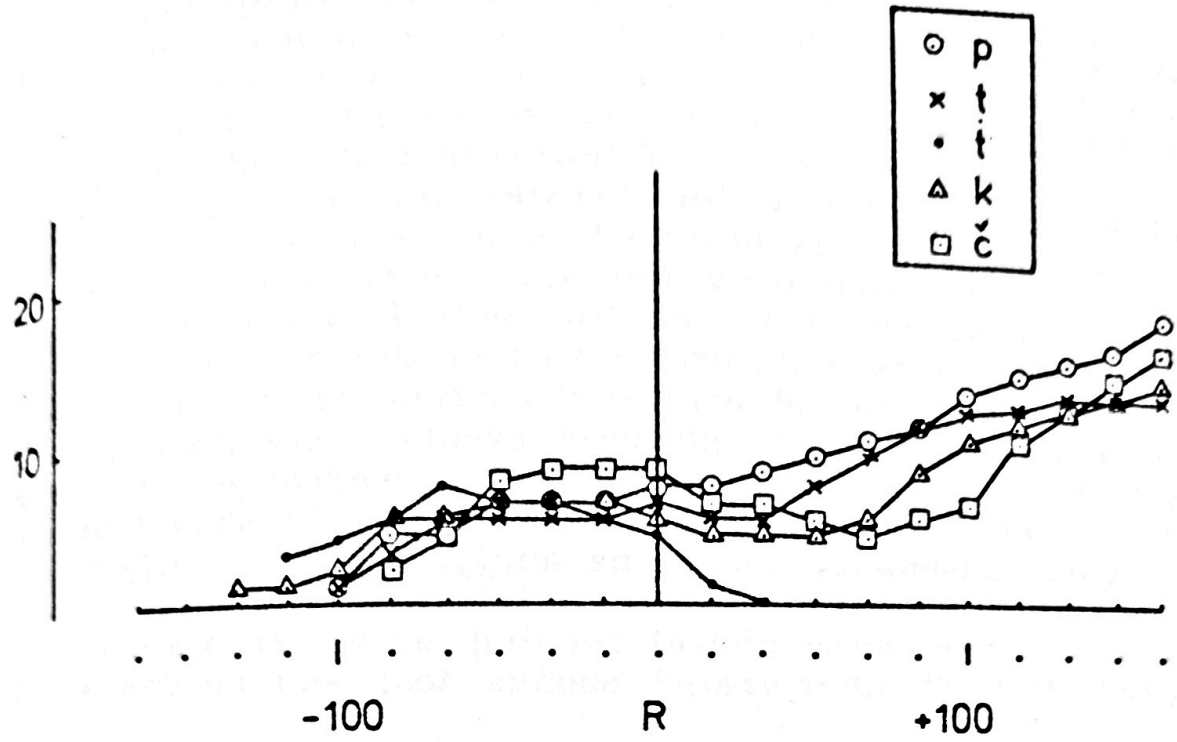

Fig.3.17: Average glottal width contours for intervocalic [t] and word final [p, ṭ, č, k].

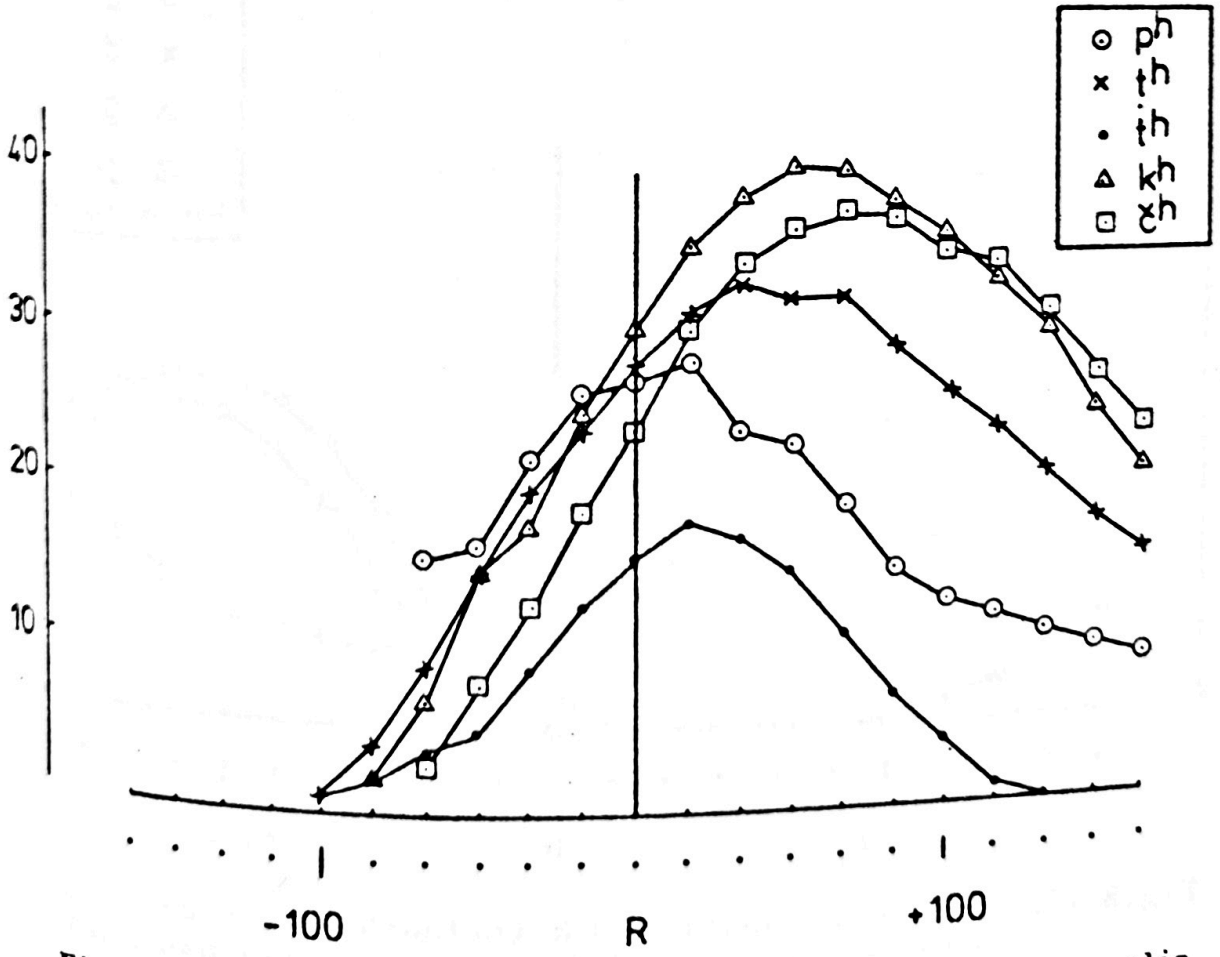

Fig.3.18: Average glottal width contours for intervocalic [tʰ] and word final [pʰ, ṭʰ, kʰ, čʰ].

category; aspiration is greater glottal width than there would otherwise be for the corresponding voiced and voiceless consonants.

6. The timing which is important to production of aspiration is not that of voice onset but rather that of the moment of maximum glottal width. Greatest glottal width for aspirated consonants is observed to occur at or shortly after the time of articulatory release. The voicing lag observable in a subset of the environments in which such consonants appear is a natural result of this timing.
7. In the production of aspirated consonants, there is clearly a sequence of two phonetic events: closure and glottal opening. That these two independently-controllable events are sequential does not necessarily show that aspirated consonants should be analyzed *phonemically* as sequences of phonemes. While glottal opening clearly occurs after closure, some glottal opening must take place in the production of unaspirated sounds too; and no one would

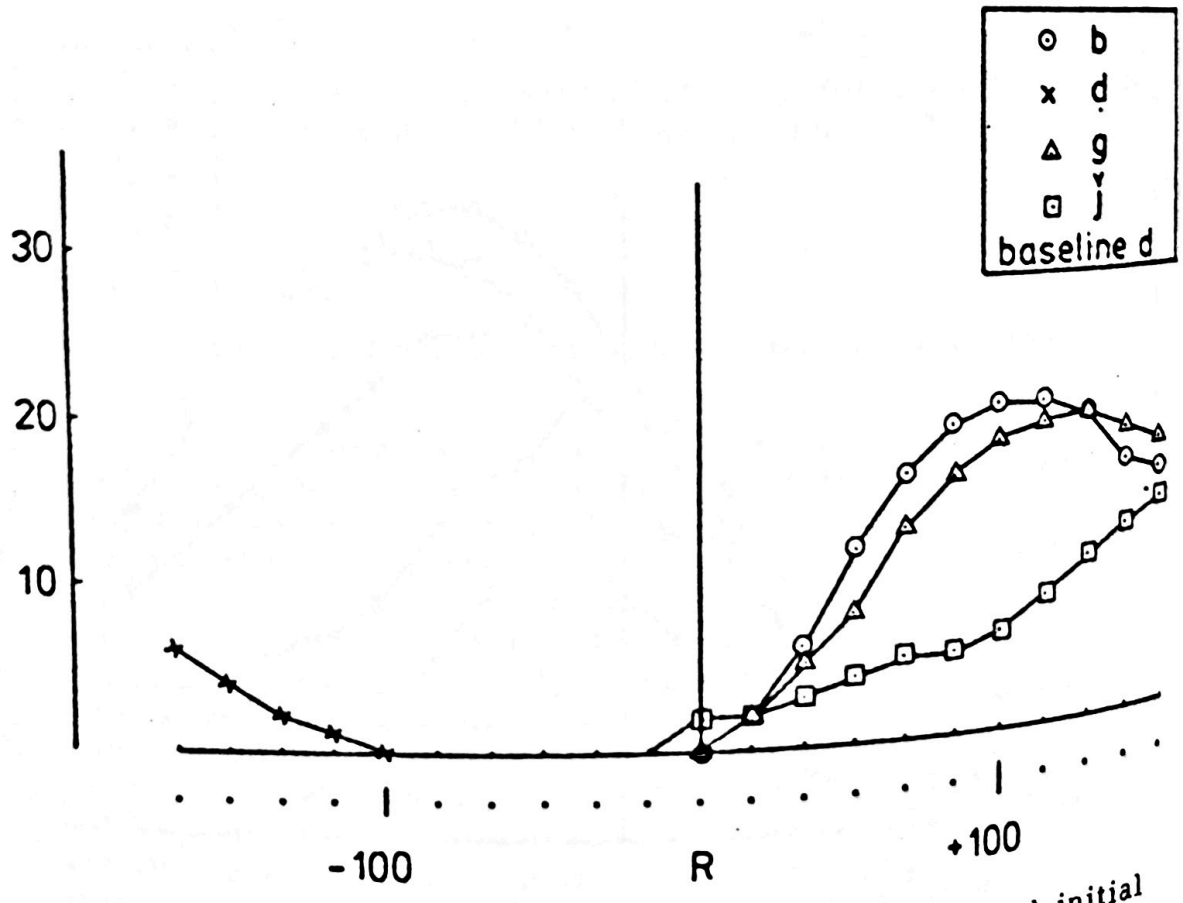

Fig.3.19: Average glottal width contours for word-initial [d], intervocalic [d] (shown on the baseline) and word-final [b, j, g].

claim that, e.g., voiced unaspirated sounds are sequences of closure + voicing.

8. Finally, sounds which are produced by a combination of vibrating vocal cords and aspiration should, in fact, be called 'voiced aspirated' consonants.

4 ACOUSTIC ANALYSIS OF ORAL AND NASALIZED VOWELS

4.1. INTRODUCTION

It has been customary among phoneticians to describe the vowels of a language in terms of articulatory movements. It is also common to describe the vowel impressionistically in reference to the Cardinal Vowels of Daniel Jones (1956). A case in point is S.Jha's (1941:436) description of Maithili "short" [i], which runs as follows:

> Short [i] may be about 1/3 away from the Cardinal [i] towards the Cardinal [e], and approaches a central place...

In his earlier publications, Ladefoged (1967:84-85; 1971:69-71, for example) had argued that the traditional articulatory descriptions of vowels were less precise than we would like and had proposed instead acoustic descriptions:

> In descriptions of vowels, although a pseudo-articulatory terminology may provide an adequate set of labels for auditory descriptions, we have seen that we do not have, as yet, a set of articulatory parameters which will specify vowel quality. Accordingly, we must consider whether the vowel continuum can be better described in terms of acoustic parameters (Ladefoged 1971:71).

But in a recent publication (1979), he has modified his position. In this study, he offers about 17 articulatory parameters and about the same number of acoustic parameters, and concludes that both sets of parameters are necessary for adequate linguistic phonetic descriptions:

> I used to think (Ladefoged 1971, 1975) that all but a few features which I termed cover features, could be defined in terms of either simple articulatory scales, or simple acoustic scales. It now appears to me that this is an oversimplification, and that very few features can be simply correlated with any of the minimal phonetic parameters.
>
> (Ladefoged 1979:15)

Lindau (1978) also has shown that some features of vowels may in fact be described as well in articulatory terms as in acoustic terms. She conludes:

> If Ladefoged were correct in claiming that vowels are better described in terms of the highest point of the tongue, then the auditory chart should correlate significantly better with the acoustic chart than with the articulatory one. However, the results do not support Ladefoged's claim.
>
> (Lindau 1978:543)

Since neither the articulatory nor the acoustic parameters have clear and indisputable priority over the other, and since it is more convenient to make a spectrographic study, the present chapter will give an acoustic description of the Maithili oral and nasalized vowels. The main objectives of the acoustic analysis are to determine:

(i) the frequency of each of the three formants (F_1, F_2 and F_3) for all oral and nasalized vowels;
(ii) the duration of each of the oral and nasalized vowels;
(iii) the effect of consonant aspiration on vowel duration;
(iv) the effect of nasalization on vowel formants;
(v) the differences between the acoustic properties of oral and nasalized vowels.

4.2. EXPERIMENTAL METHOD

4.2.1. Test Material

Maithili has eight oral vowel phonemes -- /i e æ ə a ɔ o u/. All these vowels may also be nasalized underlyingly. For this study of the formant frequencies of Maithili vowels, a list of Maithili vowels in isolation and within a word was prepared and recorded. These words were primarily monosyllabic and of the CV(C) type. Table 4.I lists the test utterances used in this study.

(A)			(B)		
	i	ĩ		[cit̆]	'flat'
	e	ẽ		[čet]	'alert'
	æ	æ̃		[læt]	'will bring'
	ə	ə̃		[lɔt]	'skewed'
	a	ã		[sət]	'true'
	ɔ	ɔ̃		[sat]	'seven'
	o	õ		[pot]	'paint'
	u	ũ		[put]	'son'
(C)	[gĩj̆]	'mishmash'	(D)	['isa]	'Jesus'
	[gũj̆]	'echo'		['hĩsa]	'share'
	[kʰẽkʰ]	'entreat piteously'		[sæ]	'thus'
	[kʰõkʰ]	'cough'		[sæ̃]	'husband'
	[hə̃s]	'laugh'		[bas]	'living'
	[hãs]	'swan'		[bãs]	'bamboo'
	[sæ̃]	'husband'		[kʰoj̆]	'search'
	[sɔ̃]	'from'		[kʰõj̆ʰ]	'dark corner'
				[us]	'whitener'
				[ũkʰ]	'sugar cane'

Table 4.I: List of Maithili Vowels in Isolation and Within a Word

4.2.2. Apparatus

Three recordings of each test item were made on an Akai Gx 365 reel-to-reel taperecorder in a soundproof studio of the Language Laboratory of the University of Kansas. The recordings were made on Scotch magnetic tape at the speed of 7½ inches per second. Wideband spectrograms and wideband sections of each token were made on a Kay Sonograph 6061B with an AGC setting of 0, except for the nasalized vowel [ũ] for which the AGC was set at 3½, in order to produce tracings of the low amplitude upper formants.

4.2.3. Formant Measurements

The formant frequency was measured from wideband spectrograms, since wideband spectrograms were found to be the most convenient way of locating the center frequency of the formant. In cases which presented difficulty, the formant frequency was determined by a comparison between the wideband spectrograms and the wideband sections. Such difficulty was encountered mostly in determining the first formant frequency of the vowels [ə a æ ɔ] because of the presence of high amplitudes at lower frequencies. The difficulty was exacerbated because of the extreme proximity of the first and second formants.

4.3. RESULTS AND DISCUSSION

4.3.1. Oral Vowels

4.3.1.1. Formant Frequency

The formant frequencies measured for oral vowels are given in Tables 4.II and 4.III and Figures 4.1 - 4.4. Tables 4.II and 4.III list the formant frequencies (in Hz) of three tokens each of the Maithili oral vowels spoken in isolation and within a word, respectively. A broken line in the tables indicates that it was not possible to ascertain the formant frequency of that particular token because nothing was seen on the spectrogram. A question mark indicates some doubt about the measurement. The averaged frequencies of the first and second formants of the vowels in Tables 4.II and 4.III are plotted in Figure 4.I for comparison of vowels in isolation and vowels in words.

It should be noted that the Maithili so-called "central" vowels [ə a], when spoken in isolation, cannot be adequately differentiated in terms of their formant frequencies alone. The acoustic spectra of [ə] and [a] look remarkably similar and it is only by having recourse to the parameter of duration that we can satisfactorily account for the perceptual difference between [ə] and [a]: [a] is intrinsically longer in duration than [ə] (see page 99).

Figure 4.2 compares the averaged values of the first two for-

Vowel	Token	F_1	F_2	F_3
[i]	1	290Hz	2580Hz	----
	2	290	2585	3585Hz
	3	250	2585	3670
	Average	277	2583	3627
[e]	1	460	2170	2790
	2	415	2250	2750
	3	415	2250	2750
	Average	430	2223	2763
[æ]	1	830	1830	2330
	2	830	1830	2330
	3	870	1870	2330
	Average	843	1843	2330
[ə]	1	790	1210	----
	2	790	1250	2750
	3	750	1250	2750
	Average	777	1237	2750
[a]	1	830	1330	2290?
	2	880	1250	2625
	3	830	1250	2585
	Average	847	1277	2500
[ɔ]	1	585?	830	2875
	2	540	830	2875
	3	500	880	2830
	Average	542	847	2860
[o]	1	460	750	----
	2	415	750	2750
	3	460	830	2830
	Average	445	777	2790
[u]	1	330	790	----
	2	330	750	----
	3	330	790	----
	Average	330	777	----

Table 4.II: Formant Frequencies of Maithili Vowels in Isolation

Vowel	*Word*	*Token*	F_1	F_2	F_3
[i]	[čit]	1	330Hz	2330Hz	3000Hz
		2	330	2330	2915
		3	290	2375	2915
		Average	317	2345	2943
[e]	[čet]	1	415	2085	2875?
		2	415	2170	2790
		3	415	2170	2830
		Average	415	2142	2832
[æ]	[læt]	1	830	1880	2330
		2	875	1830	2330
		3	875	1880	2330
		Average	860	1863	2330
[ə]	[sət]	1	750	1250	2620
		2	750	1250	2670
		3	725	1170	2670
		Average	742	1223	2653
[a]	[sat]	1	915	1415	2620
		2	880	1415	2710?
		3	880	1375	2710?
		Average	892	1402	2680
[ɔ]	[lɔt]	1	540	915	----
		2	540	915	2750
		3	585	915	2670
		Average	555	915	2710
[o]	[pot]	1	460	915	----
		2	415	830	2875?
		3	460	915	2830?
		Average	445	887	2852
[u]	[put]	1	330	830	----
		2	330	790	----
		3	330	830	----
		Average	330	817	----

Table 4.III: Values in Hz of the First Three Formants (F_1 F_2 F_3) For Maithili Vowels Spoken Within a Word

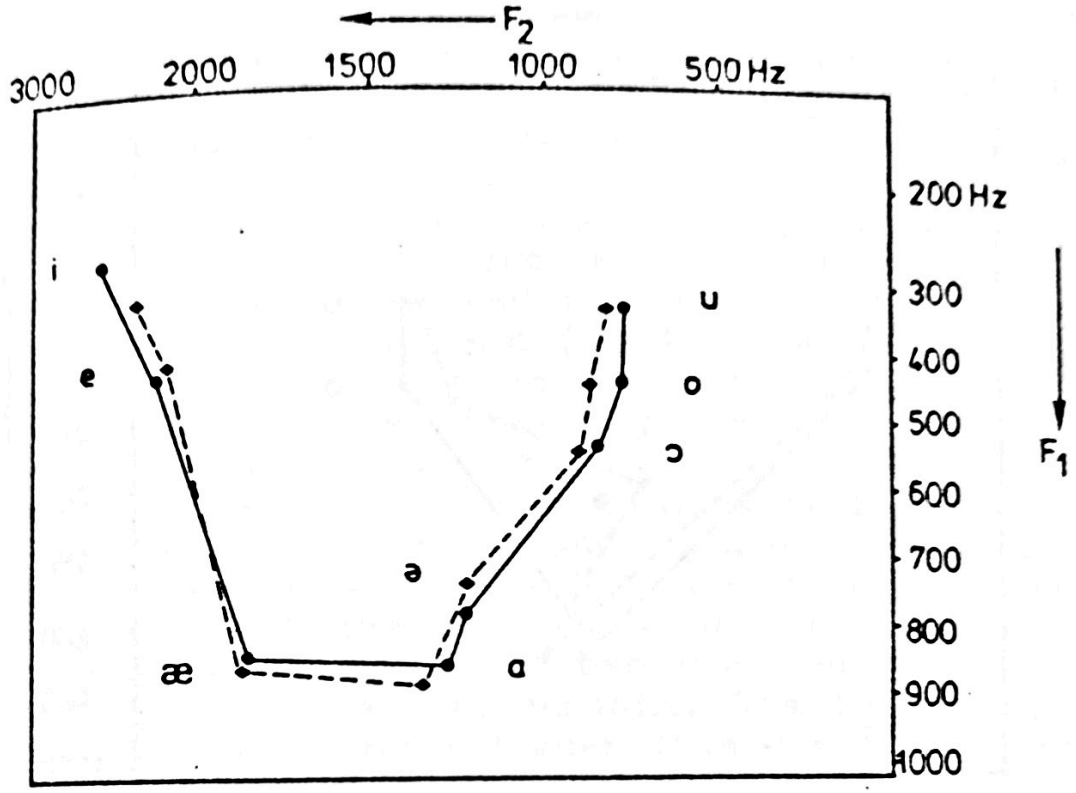

Fig.4.1: Average values of the First and Second Formant Frequencies of Maithili vowels spoken in isolation (connected line) and within a word (broken line).

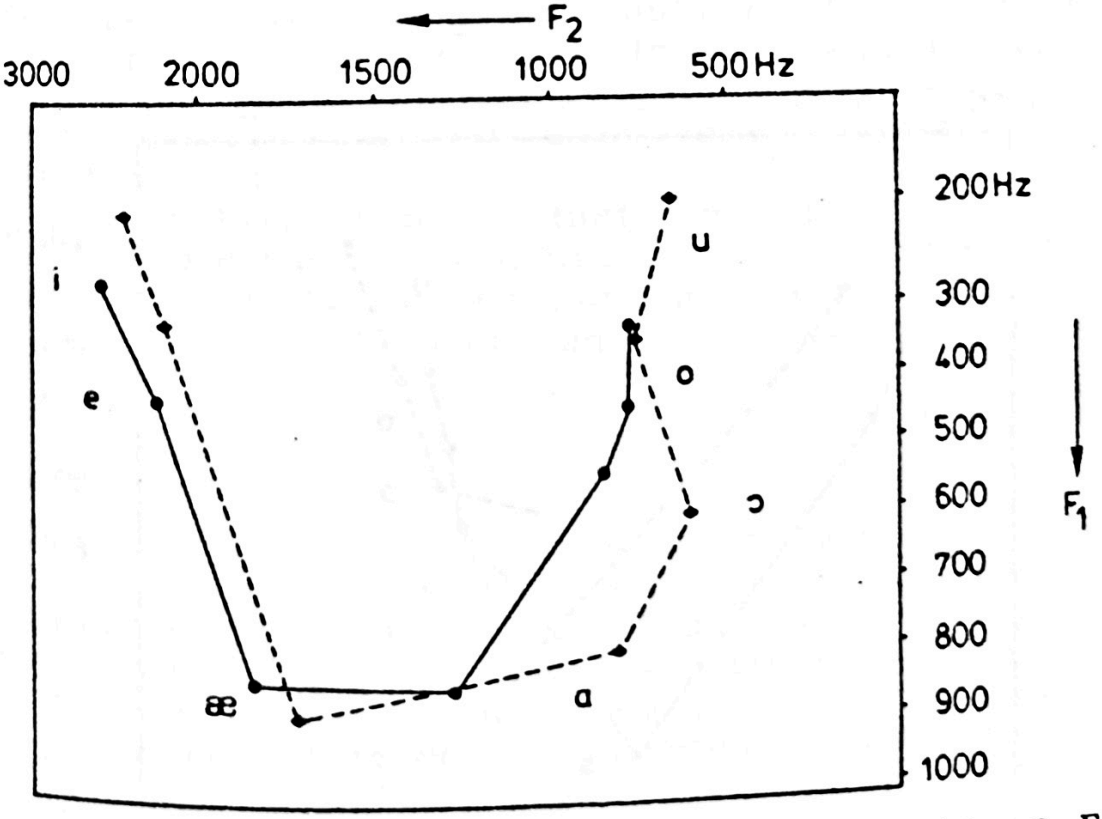

Fig.4.2: Average values of the first two formants (F_1 & F_2) for Maithili vowels spoken in isolation (connected line) and for the Cardinal vowels of Daniel Jones (broken line) as reported in Ladefoged (1959).

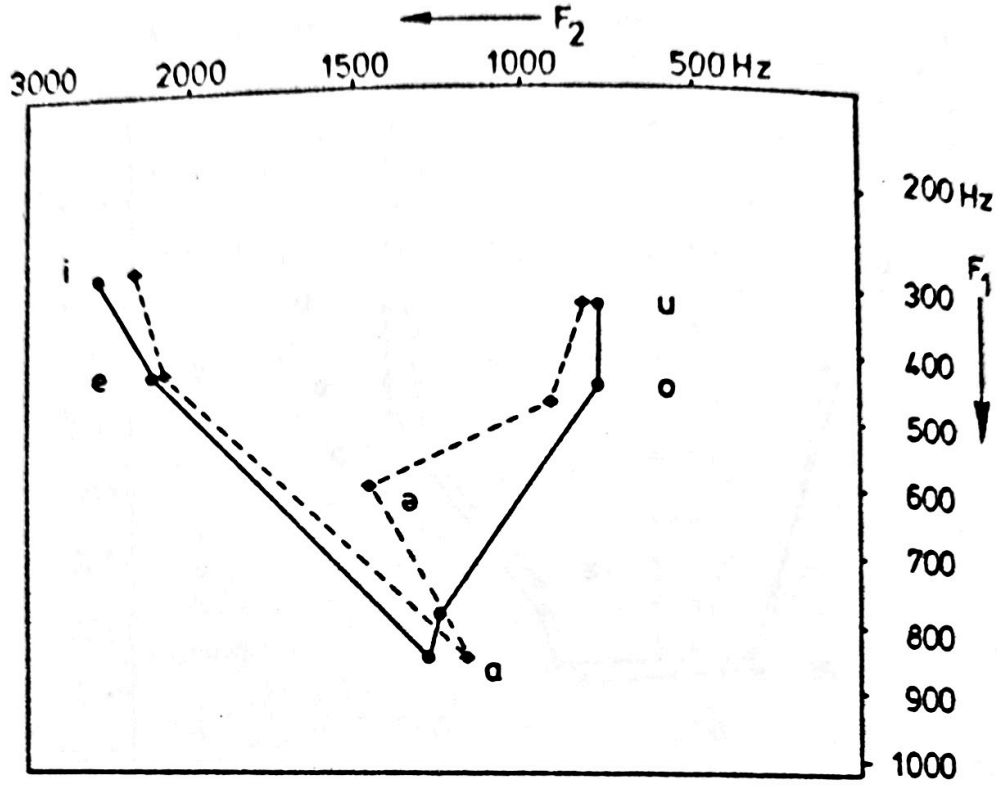

Fig.4.3: Average values of the first two formants (F_1 & F_2) for some of the Maithili vowels (connected line) spoken in isolation and for Gujarati vowels (broken line) spoken in isolation as reported by Dave (1977:216).

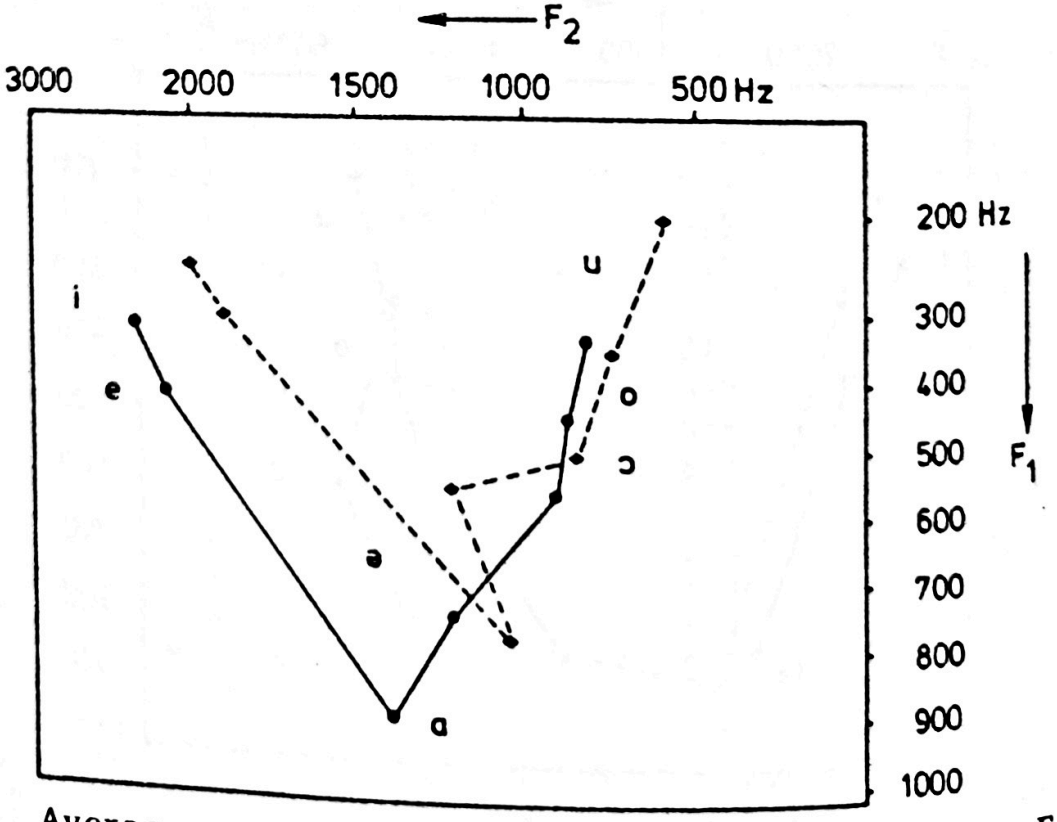

Fig.4.4: Average values of the first two formants (F_1 & F_2) for some Maithili vowels (connected line) spoken within a word and for Hindi vowels (broken line) spoken within a word as reported in Mittal and Gupta (1971:130).

mants (F_1 and F_2) for Maithili vowels spoken in isolation with the Cardinal Vowels of Daniel Jones as reported by Ladefoged (1959). The figure shows that both the F_1 and F_2 values for the majority of Cardinal Vowels are lower than those for the Maithili vowels. The only exceptions are the Cardinal [æ] which has a slightly higher F_1 value and the Cardinal [o] which has approximately the same F_2 value as both the Maithili vowels [o] and [u]. It should be noted that the Cardinal Vowel plot is distorted in the area of [a] and [ɔ] because Ladefoged provides only one formant frequency measurement in the area of F_1 - F_2 for each. These vowels have been entered in the diagram as if F_1 and F_2 had identical formant frequencies.

Figure 4.3 compares the averaged values of the first two formants (F_1 and F_2) for Maithili vowels spoken in isolation with the Gujarati vowels spoken in isolation as reported by Dave (1977: 216). In this instance, the F_1 values for the vowels of the two languages are virtually identical, excepting for [ə], which has a higher F_1 and lower F_2 in Maithili. The F_2 values for the Maithili [i] is also slightly higher than for the corresponding Gujarati vowel. Nevertheless, except for [ə], the overall pattern of the acoustic data for the two languages is the same.

Figure 4.4 presents a comparison between the averaged values of the first and second formant frequencies of the Maithili vowels spoken within a word and those of the Hindi vowels spoken within a word as reported by Mittal and Gupta (1971:130). In this instance, the figure shows that both the F_1 and F_2 values for the Maithili vowels are slightly higher than for the Hindi vowels -- perhaps because of the smaller sized vocal tract of the speaker recorded for this study.

To sum up thus far, we notice that the Maithili vowels, except for [ə] & [a], are easily differentiated in terms of their formant frequencies, and that the overall pattern of the acoustic data for the vowels of Maithili, Gujarati and Hindi is more or less the same.

4.3.1.2. Duration

Previous studies of vowel duration in various languages, including English, have shown that some of the factors affecting vowel duration are: (i) the degree of opening of the vowel; (ii) certain properties (voice, place and manner of articulation, and "force" of articulation) of the following consonant; (iii) linguistic structure, i.e., the nature of the phonemic contrasts employed by a given language; and (iv) the amount of glottal opening and airflow (Belasco 1953; Chen 1970; Chomsky and Halle 1968; Fischer-Jorgensen 1964; Halle and Stevens 1967; House 1961; House and Fairbanks 1953; Peterson and Lehiste 1963; and Zimmerman and Sapon 1958). Little, however, has been published on the effect of the fourth factor, i.e., aspiration, on vowel duration. Recently,

in a study of Hindi (standard Delhi) vowel [ə], Maddieson and Gandour (1976) have found an interaction between aspiration and vowel duration. A later study of Maddieson (1977) of five languages (Assamese, Bengali, Hindi, Marathi and Eastern Armenian) showed that vowel lengthening before aspirated consonants is not a universal. The present section examines the influence of postvocalic consonants (voiceless unaspirated, voiceless aspirated, voiced unaspirated and voiced aspirated) on vowel duration in Maithili.

4.3.1.2.1. Experimental Method

Materials

Twenty-eight monosyllabic minimal word pairs differing only in the final consonant were embedded in the sentence frame [pʰer ekber --- kəhu] 'please say --- once again'. The test words (given in Table 4.IV) included 17 consonants in final position: [p, b, bʰ; t, tʰ, d, dʰ; ṭ, ṭʰ; č, čʰ, ǰ, ǰʰ; k, kʰ, g, gʰ] and six vowels [i, e, ə, a, o, u]. The sentences were randomized and three recordings of the randomized sentences were made. The sentences were spoken in an informal style at normal conversational speed and without contrastive stress on the test words.

Apparatus

Three recordings of each sentence were made on a Uher Royal DeLuxe tape recorder. Eighty-four (28 x 3) wideband spectrograms were made on a Kay Sonagraph 6061B.

4.3.1.2.2. Measurements

The first measurements of vowel length were made from the start of the vowel to the closure for the following consonant. In the case of words beginning with voiced or unaspirated voiceless stops, the measurement began at the release of the initial stop. After voiceless aspirated stops, the onset of voicing was used as the starting point. The results of these measurements are given in Table 4.V and Figure 4.5.

Table 4.V shows vowel duration in msec for each of the three utterances of each word, the average duration of vowels, and the ratio of vowel duration preceding voiced and aspirated consonants to the duration of vowels preceding voiceless unaspirated consonants. Thus, for example, the mean vowel duration in 3 tokens of the word [bič] and [bičʰ] were 128 msec and 147 msec, the vowel preceding the aspirated consonant being 19 msec longer, with an average ratio of 1.00 to 1.14. Similarly, the average vowel durations in 3 tokens of the words [biǰ] and [biǰʰ] were 170 msec and 183 msec, the vowel before the voiced aspirated consonant being 13 msec longer, with an average ratio of 1.00 to 1.07.

Other vowels too have substantially longer average durations

[i]		[e]		[ə]	
[bič]	'center'	[k^{h}ep]	'times'	[gəp]	'talk'
[bič^{h}]	'pick up!'	[k^{h}eb]	'sail'	[gəb]	'a seeding ready to be transplanted'
[biǰ]	'seed'	[k^{h}eb^{h}]	'plant seeds'	[gəb^{h}]	'pregnancy' (i.e. of paddy crops) -- a metaphorical use.
[bij^{ɣh}]	'rust'	[bed]	'vedas'	[həṭ]	'move'
[bik]	'sell'	[bed^{h}]	'pierce'	[həṭ^{h}]	'obstinacy'
[bik^{h}]	'poison'				
[u]		[o]		[a]	
[kut^{h}]	'push; add pressure'	[kot]	'a muslim celebration'	[bat]	'matter; talk'
[kud]	'jump'	[kot^{h}]	'sour'	[bat^{h}]	'pain'
		[kod]	'dig'	[bad]	'after'
				[bad^{h}]	'out into the fields'
				[bak]	'speech'
				[bag]	'garden'
				[bag^{h}]	'tiger'

Sentence frame: [p^{h}er ekber -- kəhu]
'again once say'

Table 4.IV: Test Words

before the voiced and aspirated consonants than before their voiceless unaspirated counterparts, with the exceptions of [ə] in [həṭ] and [həṭ^{h}] and of [o] in [kot] and [kot^{h}] in which cases the average durations are only slightly longer. The measurements clearly show that the aspiration of the following consonant does seem to affect vowel duration in Maithili.

Average vowel durations are also shown in Figure 4.5. The abscissa shows the postvocalic consonants of various places of articulations that occur while the ordinate shows the vowel duration in msec. From the limited data presented here, nothing definitive

	Following Consonant	[i]			Average	Ratio		Following Consonant	[e]			Average	Ratio
bi-	č	135	115	135	128	1.00	k^he-	p	130	125	130	128	1.00
	$č^h$	150	150	140	147	1.14		b	175	150	150	158	1.23
	ǰ	175	160	175	170	1.32		b^h	180	160	180	173	1.35
	$ǰ^h$	190	165	185	183	1.42							
	k	130	115	130	125	1.00	be-	d	180	170	175	175	1.00
	k^h	140	140	145	143	1.14		d^h	190	190	180	187	1.06
		[u]							[o]				
ku-	t^h	115	125	125	122	1.00	ko-	t	150	150	160	153	1.00
	d	135	135	150	140	1.14		t^h	165	150	165	160	1.04
								d	185	160	160	168	1.09
		[ə]							[a]				
gə-	p	165	150	170	162	1.00	ba-	t	165	160	180	168	1.00
	b	210	200	215	208	1.28		t^h	175	185	195	185	1.10
	b^h	220	220	220	220	1.35		d	175	190	195	187	1.11
								d^h	190	190	210	197	1.17
hə-	ṭ	115	140	150	135	1.00		k	180	185	185	183	1.00
	$ṭ^h$	120	150	150	140	1.03		g	200	205	200	202	1.10
								g^h	215	215	215	215	1.17

Table 4.V: Vowel Duration (in msec)

can be said about the influence of place of articulation of the following consonant on vowel length.

In three words beginning with the voiceless aspirated consonant /k^h/, an additional measurement of vowel duration was also made from the release of the initial consonant to the closure for the final consonant. These measurements are shown in Table 4.VI A. Figure 4.6 shows the average vowel duration of [e] as derived from the two types of measurement, i.e., (i) from onset of voicing to the closure for the following consonant (connected line), and (ii) from the release of the preceding consonant to the closure for the following consonant (broken line). The figures for the second type of measurement are naturally higher since the duration of the initial aspirated release is also included in them. Including aspiration in the measurement does not affect the general pattern of increased duration before voiced + aspirated consonants. Table 4.VI B shows that the duration of aspirated release in the words

	Following Consonant	[e] 1	2	3	Average	Ratio
k^he-	p	210	200	300	203	1.00
	b	240	215	220	225	1.10
	b^h	255	220	240	238	1.17

Table 4.VI A: Vowel Duration (in msec) of [e]

Before	1	2	3	Average
-ep	80	75	70	75
-eb	65	65	70	67
$-eb^h$	75	60	60	65

Table 4.VI B: Duration of Initial k^h- Release

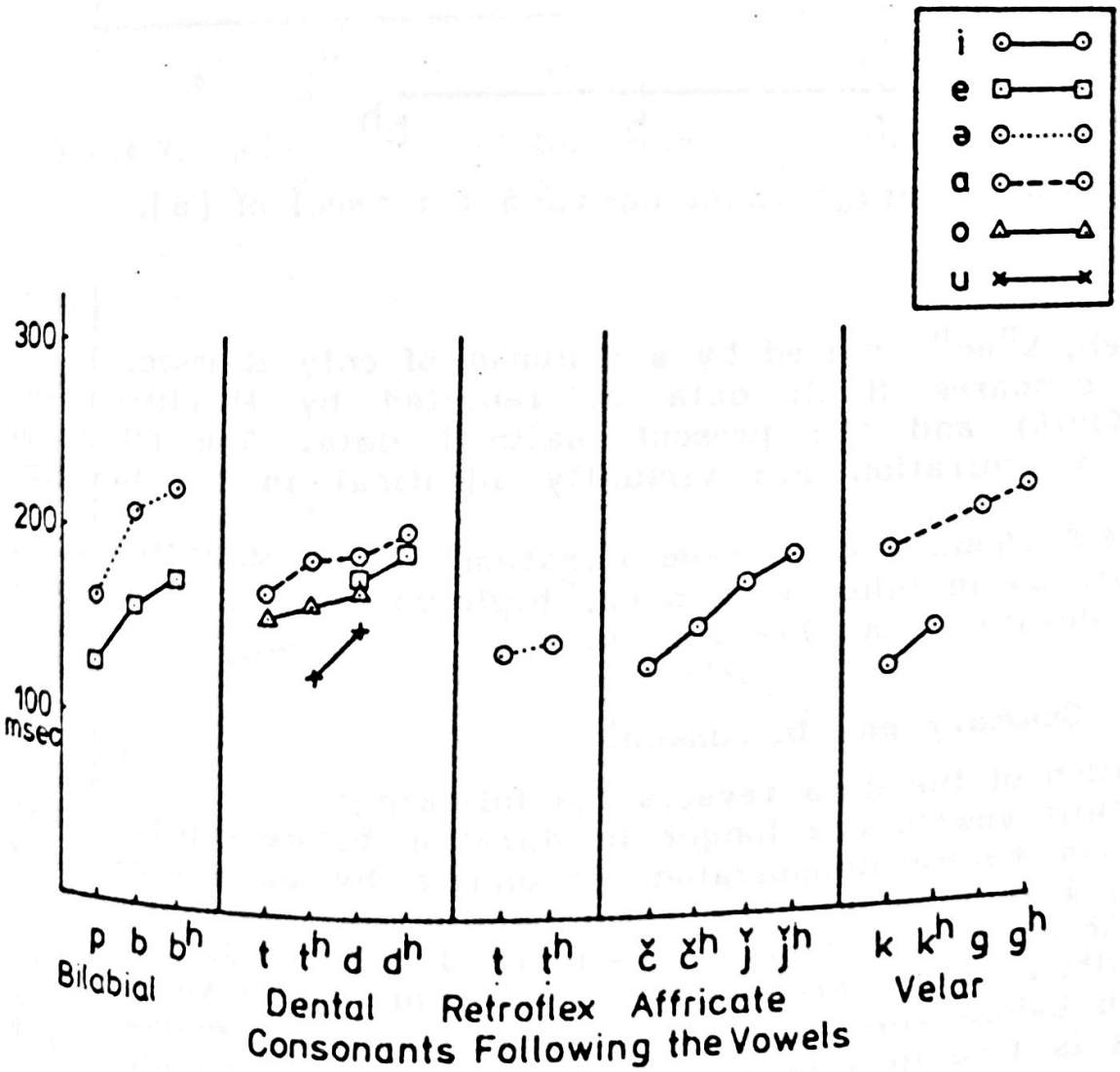

Fig.4.5: Average Vowel Duration (in msec).

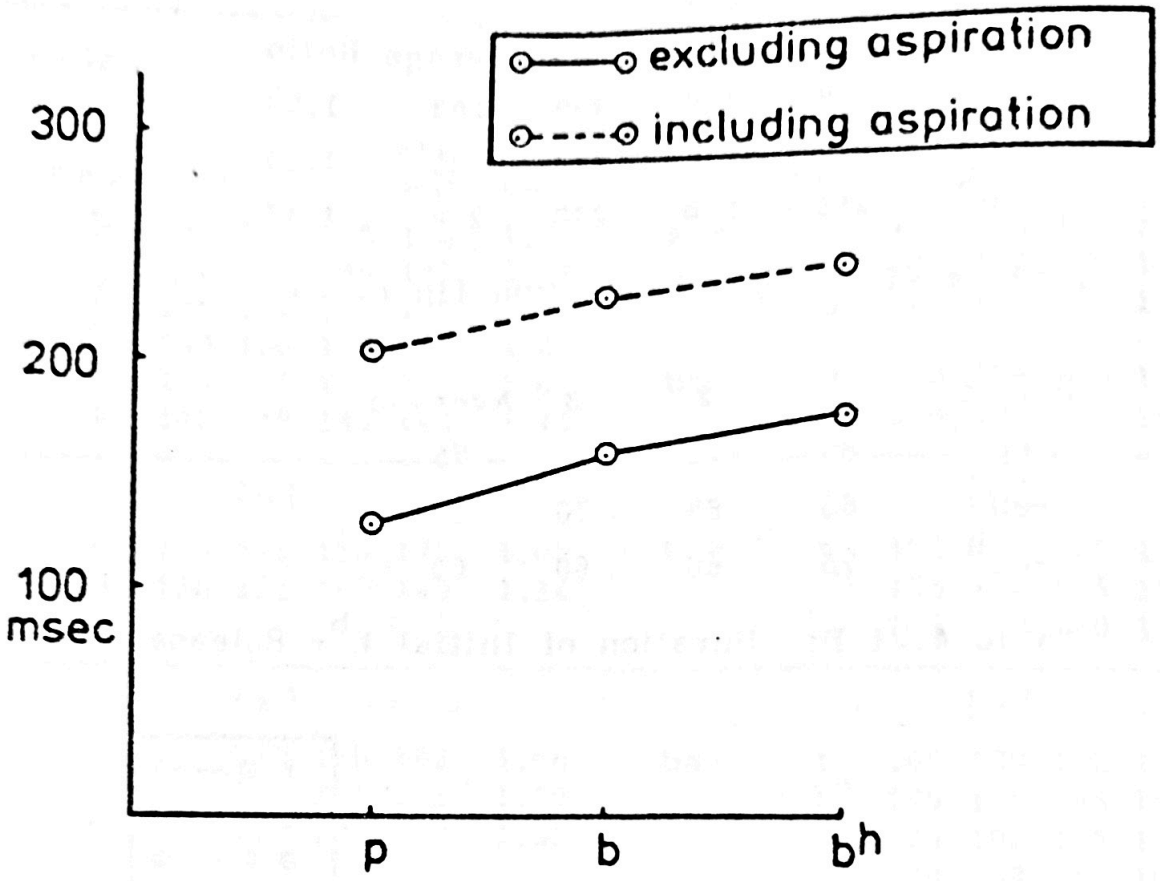

Fig.4.6: Average Vowel Duration (in msec) of [e].

[k^hep, k^heb, k^heb^h] varied by a minimum of only 20 msec.

Fig.4.7 compares Hindi data as reported by Maddieson and Gandour (1976) and the present Maithili data. The effects of voicing and aspiration are virtually identical in the two languages.

Figure 4.8 shows the average duration of the Maithili vowels. In Maithili, as in other languages, high vowels are intrinsically shorter in duration than low vowels.

4.3.1.2.3. Summary and Discussion

Examination of the data reveals the following:

(i) Maithili vowels are longer in duration before aspirated consonants than before unaspirated consonants by an average ratio of 1.00 to 1.07. The average ratio before voiceless consonants is 1.00 to 1.08 and before voiced consonants 1.00 to 1.06.

(ii) Maithili vowels are longer in duration before voiced consonants than before voiceless. The average ratio before unaspirated consonants is 1.00 to 1.18 and before aspirated consonants is 1.00 to 1.12.

(iii) The combined effects of voicing and aspiration produce an average ratio of 1.00 to 1.25 between voiceless unaspirated and

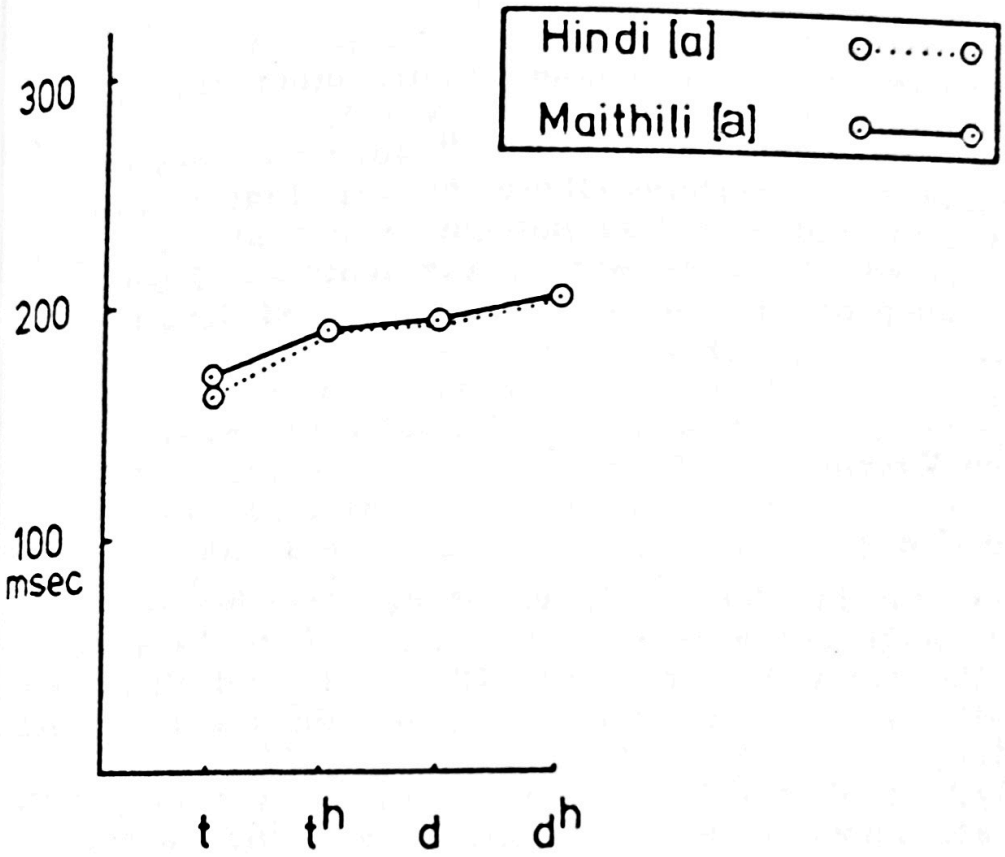

Fig.4.7: Average Vowel Duration (in msec) of Hindi [a] and Maithili [a].

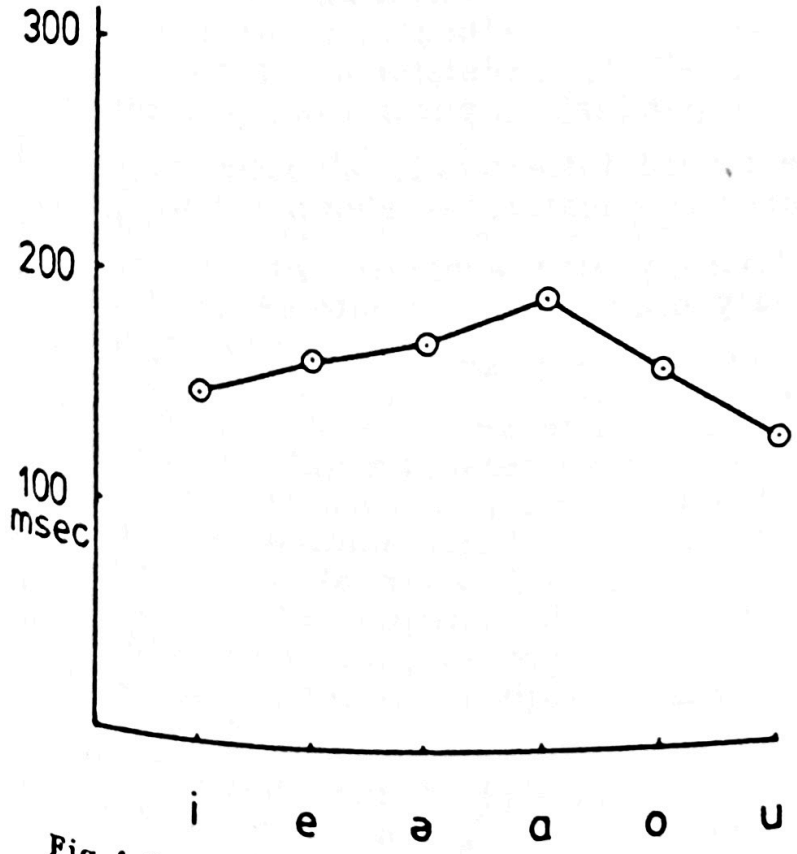

Fig.4.8: Average Vowel Duration (in msec).

voiced aspirated consonants.

(iv) The data support the generalization that vowel duration appears to be correlated with tongue-height; other things being equal, a high vowel is shorter than a low vowel.

(v) The data offer support for the traditional grouping of Maithili consonants (and perhaps those of all Indic languages) not only into voiced and voiceless categories but also into aspirated and unaspirated. In other words, the features of both voice and aspiration independently lend an increment of length to the preceding vowel.

4.3.2. Nasalized Vowels

4.3.2.1. Introduction

As has been shown in Chapter 2, vowel nasalization is distinctive in Maithili. As early a text as the *Varṇa-Ratnâkara* , which dates back to the early 14th century, (Chatterji and Misra, eds. 1940:xl) also attests to the existence of phonemic vowel nasalization in Maithili.

Synchronically, vowel nasalization in Maithili is both phonetic and phonological. Phonetic vowel nasalization occurs whenever a vowel is contiguous to a nasal consonant, e.g.

/kan/	[kãn]	'ear'
/nak/	[nãk]	'nose'
/gam/	[gãm]	'village'
/mang/	[mãŋ]	'beg'
/bəhin/	[bə'hĩn]	'sister'
/pəhuna/	['pəhũnã]	'guest'

A third process may be termed inflexional, whereby the oral/nasalized contrast occurs paradigmatically, as shown below:

['geləŭ]	'((in) yours) went'
['geləũ]	'I/you (honorific) went'

Phonological contrasts between oral and nasalized vowels occur in other environments, for example:

/is/	'God'	/bas/	'living'
/ĩṭ/	'brick'	/bãs/	'bamboo'
/kʰet/	'field'	/sɔ/	'hundred'
/kẽt/	'cane'	/s̃ɔ̃/	'from'
/bʰæ/	'brother'	/j̆ot/	'plough'
/bʰæ̃/	'cry'	/gõt/	'press downward'
/həṭ/	'move'	/uṭʰ/	'arise'
/hə̃ṭ/	'forbid'	/ũṭ/	'camel'

Formant frequencies /F_1, F_2 and F_3) of the phonologically nasalized vowels and their duration are given in the next section.

A comparison between the spectral attributes of the oral and nasalized vowels will also be presented.

4.3.2.2. Formant Frequency

Tables 4.VII and 4.VIII list the formant frequencies (in Hz) of three tokens each of the Maithili nasalized vowels spoken in isolation and within a word, respectively. The averaged values for the first two formants of the nasalized vowels are plotted against those of the oral vowels in Figures 4.9 and 4.10.

Numerous studies have attempted to determine the acoustic correlates to vowel nasalization (House and Stevens 1956; Fujimura 1960; Fant 1960, Carré 1975; J.Ohala 1975). Most of these studies have demonstrated that the first-formant effects are the primary cue for nasality. An upward-shifted F_1 , lowered amplitude, and the presence of additional peaks at the lower frequency level are considered to be important cues to vowel nasalization.

The acoustical measurements provided in Tables 4.VII and 4.VIII and Figures 4.9 and 4.10 and inspection of formant amplitudes of the Maithili nasalized vowels suggest the following observations:

First, as fas as the first formant is concerned, there is a clear upward shift in the center frequency of F_1 for [ĩ ẽ ɔ̃ õ] as compared to their oral counterparts. For [æ̃] , F_1 is somewhat higher than [æ] when spoken in word context, but lower when spoken in isolation. The F_1 of [ũ] is not affected and is remarkably similar to that of [u]. There is, however, a clear lowering of F_1 frequency for [ə̃] and [ã] from that of [ə] and [a]. Thus it would appear that the non-low nasalized vowels of Maithili are clearly characterized by an upward shift in the center frequency of F_1, while the low nasalized vowels [ə̃ ã] are characterized by a lowering of the F_1 frequency.

Amplitude of F_1 is found to be much lower for [æ̃] , [ə̃] and [ã] than for comparable oral vowels. Similar observations have been reported by previous investigators (Delattre 1954; House and Stevens 1956; Fant 1960), who claim that the weakening of F_1 for the open nasalized vowels is an important cue for vowel nasality.

Also, additional peaks of spectral energy are seen for [ĩ] and [æ̃] at around 500 - 750 Hz and for [õ] at around 1000 - 1500 Hz.

Secondly, the F_2 frequency is also somewhat higher for the front nasalized vowels [ĩ ẽ æ̃] and for the back rounded [ɔ̃] than for their oral counterparts. A similar finding is reported for Gujarati front nasalized vowels (Dave 1977:63). The F_2 frequency is always lower for [ə̃] than for [ə]. For [ã] and [õ], the second formant frequency is lower when spoken in word context, but somewhat raised when uttered in isolation. The F_2 for [ũ] is always lower when uttered in word context. A weakening of F_2 is also evident from the spectrographs for [õ] and [ũ].

Thirdly, the front nasalized vowels [ĩ ẽ æ̃] have consistently higher F_3 than for [i e æ]. For [ə̃] and [ã] the F_3 frequency

Vowel	Token	F_1	F_2	F_3
[ĩ]	1	330Hz	2625Hz	3210Hz
	2	380	2585	3170
	3	330	2540	3170
	Average	347	2583	3183
[ẽ]	1	500	2290	2710
	2	500	2250	2790
	3	460	2370	2960
	Average	487	2303	2820
[æ̃]	1	750	2000?	2500?
	2	750	2085?	2670?
	3	750	2085?	2750?
	Average	750	2057	2640
[ə̃]	1	670	1170	2250
	2	750	1170	2250
	3	750	1170?	----
	Average	723	1170	2250
[ã]	1	830	1330	2170?
	2	830	1330	2290
	3	830	1330	2250
	Average	830	1330	2237
[ɔ̃]	1	585	915	3000?
	2	585	915	3000?
	3	540	830	2960?
	Average	570	887	2987
[õ]	1	585	880	2890
	2	500	880?	3000
	3	500	---	2915
	Average	528	880	2935
[ũ]	1	330	920?	2170
	2	330	960?	2250
	3	330	915?	2290
	Average	330	932	2237

Table 4.VII: Formant Frequencies of Maithili Nasalized Vowels in Isolation

Vowel	Word	Token	F_1	F_2	F_3
[ĩ]	[gĩĭ̯]	1	380Hz	2540Hz	3250Hz
		2	380	2585	3250
		3	380	2585?	3250
		Average	380	2570	3250
[ũ]	[gũŭ̯]	1	330	790?	2500
		2	330?	750?	2330
		3	330?	750?	2290
		Average	330	763	2373
[ẽ]	[kʰẽkʰ]	1	460	2330	3085
		2	500	2290	2790
		3	500?	2330	2830
		Average	487	2317	2902
[õ]	[kʰõkʰ]	1	415	750?	2415
		2	500	830	2330
		3	500	830?	2330
		Average	472	803	2358
[ə̃]	[hə̃s]	1	670?	1170	2170
		2	670	1170	2250
		3	710?	1170	2210
		Average	683	1170	2210
[ã]	[hãs]	1	750?	1290	2085
		2	880?	1380	2210
		3	830	1290	2210
		Average	820	1320	2168
[æ̃]	[sæ̃]	1	875	1915	2415
		2	915?	1960	2540
		3	915	1915	2330
		Average	902	1930	2428
[ɔ̃]	[sɔ̃]	1	500?	1000?	2500?
		2	585?	1000	2250
		3	585?	1040?	2250
		Average	557	1013	2333

Table 4.VIII: Values in Hz of the First Three Formants (F_1, F_2, F_3) for Maithili Nasalized Vowels Spoken Within a Word.

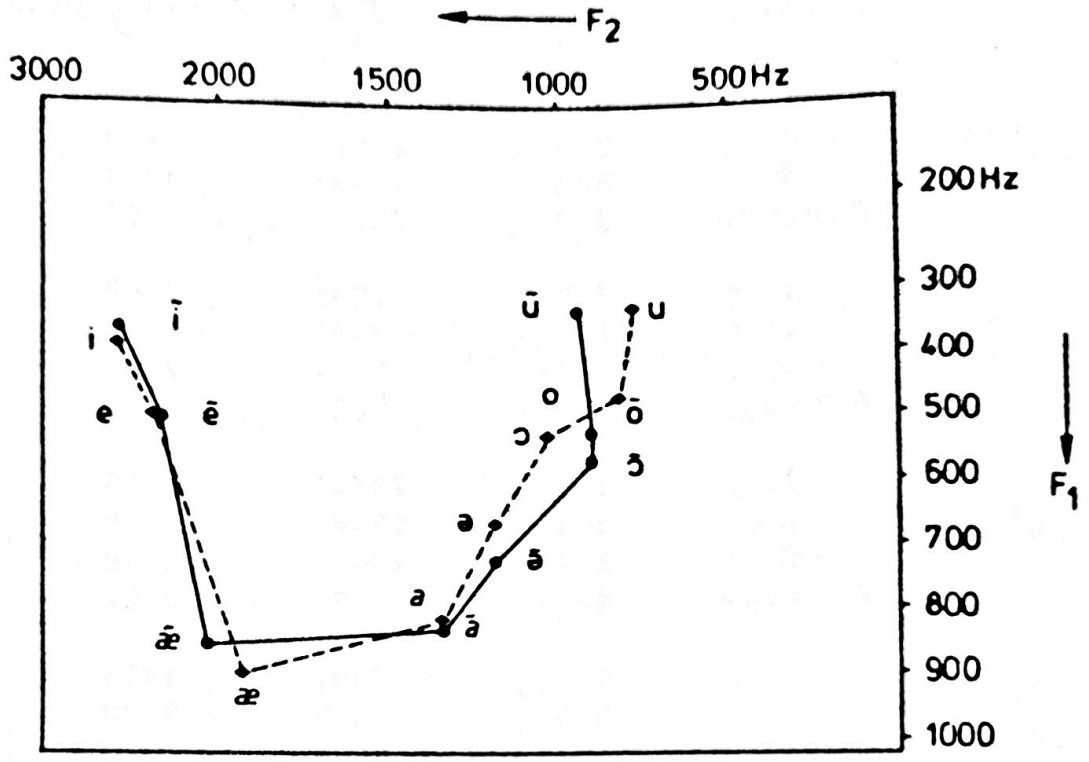

Fig.4.9: Average values of the First two Formants (F_1 & F_2) for Maithili nasalized (connected line) and oral (broken line) vowels spoken in isolation.

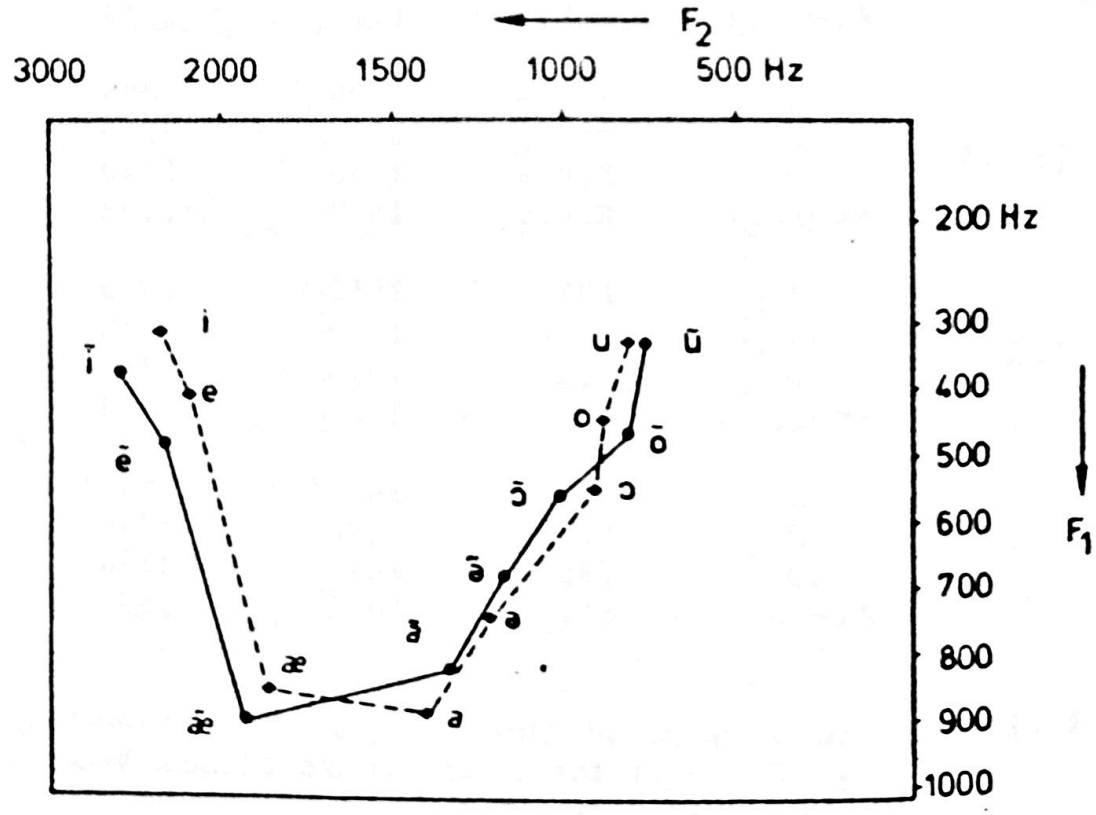

Fig.4.10: Average values of the First two Formants (F_1 & F_2) for Maithili nasalized (connected line) and oral (broken line) vowels spoken within a word.

is uniformly lower than for [ə] and [a]. For [ɔ̃] and [õ], however, the F_3 is lowered when these vowels are uttered in word context, but somewhat raised when uttered in isolation. No systematic comparison can be made between the F_3 of [ũ] and [u] because the F_3 of [u] is not to be seen.

Also, on spectrograms, the F_3 is generally seen to be much more weakened for almost all nasalized vowels, except for [ũ] in which case both the F_3 and F_4 frequencies seem to be reinforced.

4.3.2.3. Duration

In an attempt to determine the relative duration of each of the oral and phonologically nasalized vowels of Maithili, vowel duration was measured from spectrograms. The test material used for the spectrographic analysis consisted of a set of Maithili words containing both oral and nasalized vowels. Excepting for [æ] and [æ̃], these vowels occurred before a consonant. The test words are listed in Table 4.IX.

Oral		*Nasalized*	
['isa]	'Jesus'	['hĩsa]	'share'
[čet]	'alert'	[čʰẽk]	'obstruct'
[sæ]	'thus'	[sæ̃]	'husband'
[sət]	'true'	[hə̃s]	'laugh'
[bas]	'living'	[bə̃s]	'bamboo'
[lɔt]	'skewed'	[gɔ̃t]	'cattle urine'
[kʰoj]	'search'	[kʰõjʰ]	'dark corner'
[us]	'whitener'	[ũkʰ]	'sugar cane'

Table 4.IX: Test Words Containing Oral and Nasalized Vowels

Two measurements of duration were made: (i) in test words in which the vowel under investigation was followed by a consonant, the vowel duration was measured from consonant release (or voice onset after aspirated consonants) to the onset of closure for the following consonant; (ii) in the test words in which the vowel occurred word finally, vowel duration was measured from the onset of voice for the vowel to its (ultimate) offset. The results of these measurements are shown in Table 4.X.

Table 4.X shows the vowel duration in msec for each of the three utterances of each word containing oral and nasalized vowels, their average duration, and the average ratio of the duration of nasalized vowels to the average ratio of oral, i.e., non-nasalized vowels. The results show that the nasalized vowels are slightly longer in duration than the oral vowels, but the differences in duration between the non-front oral and nasalized vowels are

Oral						
Vowel	*Word*	*1*	*2*	*3*	*Average*	*Ratio*
[i]	[ˈisa]	140	130	130	133	1.00
[e]	[čet]	190	235	220	215	1.00
[æ]	[sæ]	320	300	310	310	1.00
[ə]	[sət]	180	210	200	197	1.00
[a]	[bas]	260	250	240	250	1.00
[ɔ]	[lɔt]	190	210	240	213	1.00
[o]	[$k^{h}o\check{j}$]	250	230	240	240	1.00
[u]	[us]	190	200	210	200	1.00

Nasalized						
Vowel	*Word*	*1*	*2*	*3*	*Average*	*Ratio*
[ĩ]	[ˈhĩsa]	145	135	140	140	1.05
[ẽ]	[$č^{h}ẽk$]	200	230	235	222	1.03
[æ̃]	[sæ̃]	330	310	320	320	1.03
[ə̃]	[hə̃s]	240	240	280	253	1.28
[ã]	[bãs]	300	280	250	277	1.10
[ɔ̃]	[gɔ̃t]	270	280	280	277	1.30
[õ]	[$k^{h}õ\check{j}^{h}$]	250	260	290	267	1.11
[ũ]	[$ũk^{h}$]	220	260	300	260	1.30

Table 4.X: Vowel Duration of Stressed Oral and Nasalized Vowels (in msec).

greater than those between the front vowels. Thus, while the front nasalized vowels [ĩ ẽ æ̃] are only slightly longer in duration than the front oral vowels [i e æ] with an average ratio of 1.00 to 1.05, 1.03 and 1.03 respectively, the central and back nasalized vowels [ə̃ ã õ ɔ̃ ũ] are considerably longer in duration than their oral counterparts [ə a ɔ o u] with an average ratio of 1.00 to 1.28, 1.10, 1.29, 1.11, and 1.30 respectively. Here it should be noted that for several of the pairs there is a problem in assessing the contribution of nasalization to the differences in duration because the final consonants are also different. For example, it can not be ascertained how much the greater length of [ə̃] over that of [ə] in the words [sət] and [hə̃s] is due to nasalization and how much is due to the manner of articulation of the following fricative [s].

In an electrokymographic study of phonetic nasalization in Bagheli (a dialect of Eastern Hindi), Pathak (1976:314) has also concluded that "the nasalized vowels in Bagheli have a little longer duration than their oral counterparts".

4.4. CONCLUSION

The acoustical analysis of the Maithili oral and nasalized vowels suggests the following conclusions:

(1) Except for [ə] and [a], the vowels of Maithili can be easily differentiated in terms of their formant frequencies.

(2) The so-called "central" vowels [ə a] are not fully differentiated in terms of their formant frequencies; only after having recourse to the parameter of duration are their perceptual differences fully accounted for.

(3) The duration of Maithili vowels appears to be correlated with tongue-height; other things being equal, a high vowel is shorter than a low vowel.

(4) Maithili vowels are longer in duration before voiced consonants than before voiceless.

(5) Maithili vowels are also somewhat longer in duration before the aspirated consonants than before the unaspirated.

(6) The combined effects of voicing and aspiration on vowel duration produce an average ratio of 1.00 to 1.25 between voiceless unaspirated and voiced aspirated consonants.

(7) The non-low nasalized vowels of Maithili are characterized by a higher F_1, while the low nasalized vowels [ə̃ ã] are characterized by a lower F_1. F_1 for [æ̃ ə̃ ã] are much weaker in amplitude than the F_1 of corresponding oral vowels; F_2 for [õ] and [ũ] are also weakened.

(8) F_2 values are somewhat higher for the front nasalized vowels [ĩ ẽ æ̃] and for the back rounded [ɔ̃] than for their oral counterparts. F_2, however, is always lower for [ə̃] than for [ə].

(9) F_3 values for the front nasalized vowels [ĩ ẽ æ̃] are consistently higher than for [i e æ], while these are uniformly lower for [ə̃ ã] than for [ə a].

(10) Higher formants, especially F_3, are generally weakened for the nasalized vowels, excepting for [ũ] which has stronger F_3 and F_4.

(11) Additional peaks of spectral energy are evident for [ĩ] and [æ̃] at around 500 - 750 Hz and for [õ] at around 1000 - 1500 Hz; and finally,

(12) Maithili nasalized vowels are invariably longer in duration than the oral vowels.

5 ACOUSTIC ANALYSIS OF WORD STRESS

5.1. INTRODUCTION

Maithili, like most Indo-Aryan languages, is a stress language. However, stress in Maithili is far weaker than in English. Vowel reduction in unstressed positions is not as great in Maithili as in English. Also, stress in Maithili is less significant, playing only a marginal role in distinguishing words.

This chapter will review some of the proposed stress-assignment rules for Maithili and then offer some instrumental evidence to determine the probable acoustic correlates of stress. An attempt will also be made to rewrite the stress placement rules in the light of new data.

5.2. Previous Studies

The earliest study of word stress in the Indo-Aryan languages, including Maithili, is that of Grierson (1895a) wherein he argued that these languages:

> closly follow the rules of Sanskrit stress-accent (as distinct from the ancient musical accent)... The only difference is that IAV's [Modern Indo-Aryan Vernaculars] do not usually throw the accent further back than the antepenultimate if the word ends in a long syllable. (p.139).

Grierson's (1895b, 1896) later studies also reiterate the same position.

In his earlest study (1941), S.Jha mentions word stress only briefly, but later (1958) he discusses stress in modern Maithili at greater length and offers the following stress-placement rules:

(i) Words of one syllable have their vowels always stressed.
(ii) In words of two syllables, the penultimate, i.e., the initial vowel gets the accent.
(iii) But if the final vowel is long and the initial, short, the final vowel has the accent.
(iv) In words of three syllables, if all the vowels are short or the penultimate is long, the penultimate bears the stress.
(v) If the penultimate is short and the final, long, the final syllable bears the accent.
(vi) If the other syllables are short and the ante-penultimate vowel, long, the latter bears the stress.
(vii) As stress cannot be thrown further back than the third syllable from the end the rules of accentuation in words of three syllables hold good in words of more syllables also.

(pp. 59-60)

The crucial problem with most of these previous studies, including those of Grierson, is that these are highly impressionistic. In particular, Grierson's (1895a, 1895b, 1896) studies are especially open to serious objections for the simple reason that he placed all the new Indo-Aryan languages under the same stress rules and it is not clear how large a sample he used in the ten or eleven languages he investigated. Furthermore, the stress-placement rules proposed by previous studies are based heavily on literary spelling rather than actual pronunciation -- a puristic bias to keep the pronunciation closer to Sanskrit is easily noticeable. Also, previous writers have tended to confuse stress with vowel length. For instance, to most of S.Jha's (and of Grierson's) stress-placement rules, vowel length is crucial. However, vowel length is known to be nonphonemic in Maithili. Consequently, the basic premise of these stress rules is untenable.

5.3. LOCATION OF STRESS

Trail's (1973) word list of approximately 1700 words has been used for this preliminary distributional study of the position of primary word stress in Maithili.

Monosyllabic

All monosyllabic nouns, pronouns, adjectives and verbs are always stressed, e.g.,

['i]	'this'
['ke]	'who'
['mač^{h}]	'fish'
['ḍ^{h}il]	'louse'
['pãĭk^{h}]	'wings'
['nik]	'good'
['leb]	'to take'
['deb]	'to give'
['k^{h}æb]	'to eat'

Disyllabic

All disyllabic verbs in Trail's List and a great majority of disyllabic nouns, pronouns and adjectives (approximately 75%) receive stress on their penultimate, i.e., the initial syllable. Examples:

['bəhut]	'a lot'	['kərəb]	'to do'
['ədmi]	'man'	['piəb]	'to drink'
['bekti]	'individual'	['sutəb]	'to sleep'
['ṭ^{h}ehun]	'knee'	['ladəb]	'to load'
['ẽri]	'heel'	['kaṭəb]	'to cut'
['k^{h}opri]	'hut'	['põṭa]	'nasal mucus'

Trail (1973) did not include inflected causative verb forms which may receive stress on the ultimate syllable. Examples:

[kə'ṭa] '(imp.) cause to cut'
[hə'ṭa] '(imp.) cause to move; remove'
[lu'ṭa] '(imp.) cause to rob'
[bʰə̃'ǰa] '(imp.) cause to exchange'
[pʰə̃'sa] '(imp.) cause to entangle'
[lə'da] '(imp.) cause to load'

The remaining 25% of the disyllabic nouns, pronouns and adjectives have stress on the last syllable,

[bi'rar] 'land fit to grow seedlings'
[kə'reǰ] 'heart'
[kʰə'kʰar] 'sputum'
[bo'kʰar] 'fever'
[kə'ṭʰor] 'hard'
[gə'rib] 'poor'
[gə'rur] 'a bird'
[gʰə'məṇḍ] 'pride'
[bi'laǐ] 'cat'
[lə'raǐ] 'war'
[ke'raǒ] 'beans'
[mir'čaǐ] 'hot pepper'
[čə'ṭaǐ] 'mat'

Tentatively, it may be concluded that the disyllabic nouns, pronouns and adjectives of Maithili normally receive stress on the ultimate syllable when the ultimate syllable is either closed, i.e., ends in a consonant or a cluster of consonants, or ends in a sequence of vowels -- which is diphthongized in surface phonetic forms. There are, however, exceptions, e.g.,

['bəhut] 'a lot'
['ṭʰehun] 'knee'

Trisyllabic

Nouns, Pronouns and Adjectives

The majority of trisyllabic nouns, pronouns and adjectives (approximately 75%) receive stress on the penultimate syllable. Examples:

[kən'pəṭṭi] 'temple (of the head)'
[kəṭʰ'kʰodʰi] 'woodpecker'
[bʰəg'ǰogni] 'firefly'
[ən'ṭʰanbe] 'ninety-nine'
[un'čalis] 'forty-nine'
[kən'bəlla] 'earrings'

However, a number of trsyllabic nouns, pronouns, and adjectives (approximately 18%) receive stress on the antepenultimate, i.e., the first syllable, e.g.,

['bərʰiyã] 'better'
['duniyã] 'world'

['dəhina]	'right'
['tərʰiya]	'petticoat'
['mukʰiya]	'leader'
['nariyər]	'coconut'
['ḍʰaluwa]	'steep'
['bastəbik]	'true; real'

A few trisyllabic nouns, pronouns and adjectives (approximately 7%) receive stress on the ultimate syllable. Examples:

[hosi'yar]	'alert'
[čəmət'kar]	'skill'
[bəru'war]	'strong'
[əsən'tokʰ]	'dissatisfaction'
[guri'æl]	'wrapped up'

Verbs

Most trisyllabic verb infinitives, including causal infinitives, receive stress on the penultimate syllable, e.g.

[kʰi'harəb]	'to chase'
[ni'kʰorəb]	'to clean (vegetable, grain, etc.)'
[nəŋ'raeb]	'to limp'
[kʰə'kʰarəb]	'to clear throat'
[bʰə'gaeb]	'to drive away'
[bi'yaeb]	'to give birth'
[hu'laeb]	'to pen up (animals)'
[u'kʰarəb]	'to uproot'
[kə'ṭaeb]	'to cause to cut'
[hə'ṭaeb]	'to remove'
[lə'ḍaeb]	'to cause to load'
[pʰə̃'saeb]	'to cause to entangle'

There are, however, some exceptions, e.g.

['pəhũčəb]	'to arrive'
['nihurəb]	'to bend'

What is worth noting is that such trisyllabic verbs receive stress on the same syllable as do their stems, e.g.

'pəhũč -	'arrive'
'nihur -	'bend'

Quadrisyllabic

Nouns and Adjectives

Almost all Maithili nouns and adjectives of four syllables have stress on the third syllable from the end, i.e., on the antepenultimate, e.g.

[bəm'reṭiya]	'left-handed'
[nə'čəniyə̃]	'dancer'
[u'pədrəbi]	'naughty'
[mə'ǰakiya]	'humorous'

There are, however, some exceptions. For instance, a small number of quadri-syllabic nouns and adjectives -- mostly borrowings -- receive stress on the penultimate syllable. Examples:

[əgər'bəttiˌ]	'incense' (Hindi borrowing)
[əbʰi'netaˌ]	'actor' (Sanskrit borrowing)

In compound nouns of four syllables, the two components retain their original stress patterns -- the first component having the primary stress and the second the secondary stress, e.g.

['čaru,təraphˌ]	'all around' (lit. 'four sides')
['bunə,bəla]	'weaver (lit. 'weave + doer')
[bi'rar,bəla]	'owner of the land fit to grow seedlings'
[mir'čaĭ,bari]	'pepper garden'
[ən'ṭʰanbe,sɔ]	'ninety-eight hundred'

Verbs

All verbs of four syllables receive stress on the penultimate syllable. Examples:

[pəhũ'čaeb]	'to cause to arrive; to deliver'
[gʰisi'yaeb]	'to drag'
[hərbə'raeb]	'to hurry; to rattle'
[bisbi'saeb]	'to itch'
[čulču'laeb]	'to scratch an itch'
[ḍori'aeb]	'to lead on a rope'
[bohi'aeb]	'to wallow'

Like the compound nouns, periphrastic (also called compound) verbs also retain their original stress on the components, but both components receive primary stress. Examples:

['pəčʰa 'lagəb]	'to follow'
['səŋe 'ǰaeb]	'to escort'
['muri hi'laeb]	'to nod (with head)'
['hapʰi 'kərəb]	'to yawn'
['ənḍa parəb]	'to hatch (an egg)'
['pərti 'torəb]	'to clear a field'
[de'kʰar 'kərəb]	'to expose'
[ḍʰe'kar 'kərəb]	'to belch'
[si'kar 'kərəb]	'to hunt'
[si'ŋar 'kərəb]	'to decorate'

To sum up, despite a few exceptions, the general pattern is for most verbs of Maithili to receive stress on the penultimate syllable.

5.4. ACOUSTIC CORRELATES OF STRESS

5.4.1. Experimental Method

Test Material

For this study, a list of Maithili word pairs was prepared. The word pairs were read three times in isolation and were recorded in the order presented in Table 5.I. These words were all disyllabic and of the CVCV type. The word pairs differed primarily in their stress pattern and were of the type in which one word was a noun and the other a causative verb -- with the exceptions of ['giro] 'may he fall' and [gi'ro] '(you) cause to fall', which were both verbs. Table 5.I lists the stress pairs used in this study.

['bəča]	'child'
[bə'ča]	'(cause to) save'
['suta]	'heavy thread'
[su'ta]	'cause to sleep'
['giro]	'may he fall'
[gi'ro]	'(you) cause to fall'
['gəla]	'throat'
[gə'la]	'cause to melt'
['pota]	'grandson'
[po'ta]	'cause to whitewash'

Table 5.I: Maithili Stress Pairs

Apparatus and Measurements

Three recordings of each Maithili stress pair were made on an Akai Gx reel-to-reel taperecorder in a soundproof studio of the Language Laboratory of the University of Kansas.

Fundamental frequency was measured from narrow band spectrograms by dividing by ten the frequency of the tenth harmonic. In some cases (e.g. [i o u]) where the tenth harmonic was not visible, the fundamental frequency was estimated on the basis of the frequency of the fifth harmonic.

Intensity was measured from intensity tracings produced by the F.J.Electronics Intensity Meter.

Duration was measured on both wideband spectrograms and oscillographic wave forms.

5.4.2. Results and Discussion

Results of the measurements are given in Tables 5.II - 5.V. Table 5.II lists the fundamental frequency (in Hz) measured at the

Word	Vowel	Fo (in Hz) 1	2	3	Average
['bəča]	['ə]	131	131	125	129
	[a]	114	120	125	120
[bə'ča]	['a]	134	134	125	131
	[ə]	114	103	108	108
['suta]	['u]	145	145	134	141
	[a]	103	106	131??	113
[su'ta]	['a]	131	131	131	131
	[u]	117	111	117	115
['giro]	['i]	134	134	134	134
	[o]	128	128	128	128
[gi'ro]	['o]	117	122	122	120
	[i]	128	128	128	128
['gəla]	['ə]	131	128	128	129
	[a]	114	117	134??	122
[gə'la]	['a]	122	120	122	121
	[ə]	111	114	108	111
['pota]	['o]	145	134	134	138
	[a]	123	100	134	119
[po'ta]	['a]	134	131	134	133
	[o]	106	111	106	108

Table 5.II: Peak Fundamental Frequencies (in Hz) of Maithili Stress Pairs

peak for each of the three tokens of each stress pair and their average fundamental frequency. The values show that stressed vowels in Maithili usually have a higher fundamental frequency than the corresponding unstressed vowels. On the average, a stressed vowel in Maithili has a fundamental frequency 14 Hz higher than the fundamental frequency of an unstressed vowel.

It has been known for some time that the presence or absence of voicing during consonant environment has an influence upon the fundamental frequency of the adjacent vowel. The fundamental frequencies of vowels in voiceless environments are in general higher than in voiced environments. However, as House and Fairbanks (1953:110) have concluded:

> ...the effects of consonants upon fundamental frequency, although significant, are probably less than the variations in

fundamental frequency natural to the vowels themselves when consonant environments are constant.

Other studies (Peterson and Barney 1952; Lehiste 1961, 1970), have shown that there is also a close connection between the phonetic quality of a vowel and its intrinsic fundamental frequency. Other things being equal, a high vowel has a higher fundamental frequency.

Although the corpus used in this study was extremely limited, both of the above observations are borne out by the present study. For instance, Table 5.II shows that the stressed ['a] occurring after voiceless consonants [t] or [č] have considerably higher fundamental frequency values than the one occurring after the (voiced) lateral [l]. Also, the intrinsic fundamental frequencies of Maithili vowels (computed from Table 5.II and listed in Table 5.III) show that Maithili high vowels too have higher fundamental

['i]	134Hz
['ə]	129
['a]	128
['o]	129
['u]	141

Table 5.III: Intrinsic Fundamental Frequency (Hz) of Maithili Stressed Vowels

frequencies. As a matter of fact, the results presented in Table 5.III show a striking similarity between the intrinsic fundamental frequency values obtained for English stressed vowels by Peterson and Barney (1952) (as reported in Lehiste 1970:69) and those of the Maithili stressed vowels. This similarity is shown in Figure 5.1.

Table 5.IV lists the relative intensity (in dB from an arbitrary 0) measured at the maximum level for each of the three tokens of each Maithili stress pair and their average intensity. The figures show that the stressed vowels in Maithili have a slightly higher average intensity than the unstressed vowels. On the average a stressed vowel in Maithili has a 3 dB higher relative intensity than an unstressed vowel. This is, however, not a considerable difference as compared to the 4 to 5 dB range established for American English and 12 dB range for Hungarian (as reported in Lehiste 1970:121).

Previous investigators (Fairbanks, House and Stevens 1950; Fónagy 1966; House and Fairbanks 1953; Lehiste 1961, 1970) have emphasized the connection between the phonetic quality of a vowel and its intrinsic intensity. They have also considered the differing consonant environment (especially the presence or absence

Word	Vowel	Intensity (in dB) 1	2	3	Average
['bəča]	['ə]	21.5	23.5	23	23
	[a]	19.5	21	20.5	20
[bə'ča]	['a]	20	22	22.5	21.5
	[ə]	17	18	22	19
['suta]	['u]	21	21.5	22.5	22
	[a]	18.5	18.5	21	19
[su'ta]	['a]	20.5	20	21.5	21
	[u]	17	21	21.5	20
['giro]	['i]	22.5	24	25	24
	[o]	18.5	22.5	21.5	21
[gi'ro]	['o]	22	24	24.5	23.5
	[i]	21	23.5	23	22.5
['gəla]	['ə]	22.5	23.5	23	23
	[a]	18.5	21	20.5	20
[gə'la]	['a]	20.5	22	22.5	22
	[ə]	18.5	20.5	20.5	20
['pota]	['o]	21.5	22	22.5	22
	[a]	17.5	17.5	18.5	18
[po'ta]	['a]	20	21	21	21
	[o]	15.5	18	18.5	17

Table 5.IV: Peak Intensity (in dB) Values for Maithili Stress Pairs

of voice) as an important factor in determining the intrinsic vowel intensity.

Considering the limited number of stress pairs used in this study, no claim will be made as to the intrinsic intensity of the Maithili stressed vowels. Nevertheless, looking at the intensity values provided in Table 5.IV, the following observations may be made:

(i) Studies of other languages have shown that in general a high vowel has a lower relative intensity. However, the Maithili stressed high front vowel ['i] has a high relative intensity. This may be so because the presence of the continuous voicing throughout the word ['giro] has caused the intensity to go higher. Similarly, the high relative intensity value of the Maithili stressed high back vowel ['u] may have been so because of the preceding

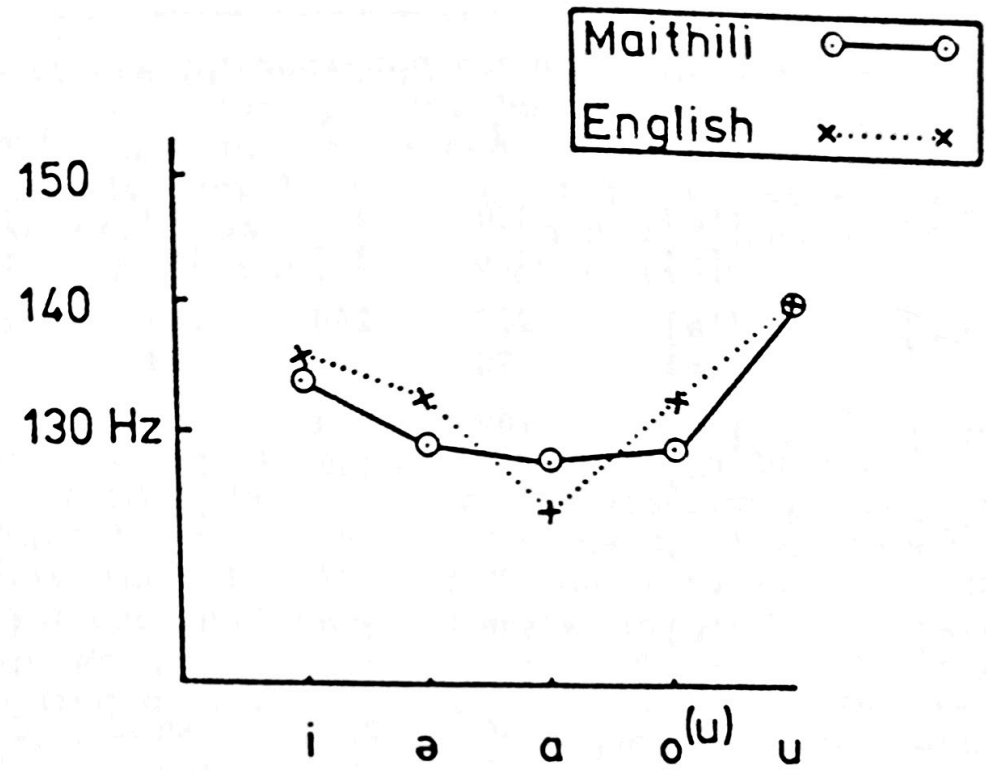

Fig.5.1: Peak fundamental frequency values for Maithili stressed vowels (connected line) as compared with the English stressed vowels (dotted line) obtained by Peterson and Barney 1952 (as reported in Lehiste 1970:69).

fricative consonant [s] in the word ['suta]

(ii) The low vowel [a] is known to have higher intrinsic intensity. However, the values registered for the stressed ['a] in this study are rather low. This may be explained in terms of the fact that all instances of [a] occur in the second syllable of the word.

(iii) Voicing of the consonant environment is known to increase the intensity of the adjacent vowel. This may be observed in the case of the stressed vowel ['o] in the word ['pota] which has a lower intensity than in the word [gi'ro] even when the stress falls on the second syllable in the latter word. Thus, it appears that voicing of the consonant environment may be a more important factor than word structure in determining the relative intensity of a vowel.

Table 5.V lists the duration (in msec) of each of the three tokens of the Maithili stress pairs and their average duration. The figures show that all the stressed vowels of Maithili are considerably longer in duration than the unstressed vowels. The greatest durational difference is observed between the stressed and unstressed [o] and [ə]: on the average stressed ['o] and ['ə] are 76 msec and 60 msec longer in duration than the unstressed [o]

Word	Vowel	Duration (in msec) 1	2	3	Average
['bəča]	['ə]	160	100	80	113 msec
	[a]	150	160	190	167
[bə'ča]	['a]	220	240	200	220
	[ə]	70	70	70	70
['suta]	['u]	100	90	100	97
	[a]	220	130	230	193
[su'ta]	['a]	200	190	220	203
	[u]	50	50	70	57
['giro]	['i]	170	120	150	147
	[o]	180	190	220	197
[gi'ro]	['o]	240	220	280	247
	[i]	100	100	100	100
['gəla]	['ə]	160	150	160	157
	[a]	180	180	190	183
[gə'la]	['a]	200	200	230	210
	[ə]	80	80	80	80
['pota]	['o]	160	160	160	160
	[a]	190	140	190	173
[po'ta]	['a]	220	220	220	220
	[o]	50	70	50	57

Table 5.V: Duration (in msec) of Maithili Stress Pairs

and [ə] -- with the average ratio of 1.00 to 1.59 and 1.00 to 1.80, respectively. Similarly, on the average stressed ['i], ['u] and ['a] are 47 msec, 40 msec and 34 msec longer than the unstressed [i u a] respectively -- with the average ratio of 1.00 to 1.47, 1.00 to 1.70 and 1.00 to 1.18, respectively. On the average, a stressed vowel in Maithili is about 50 msec longer in duration than an unstressed vowel.

Duration is a much more robust cue of word stress in Maithili than fundamental frequency since no particular pitch contour can be observed to correlate well with stress. For instance, the word pairs ['giro] and [gi'ro] cannot be differentiated on grounds of pitch since no difference in pitch contour is observed on the narrow band spectrograms: both words have rising pitch on the first vowel followed by a falling pitch on the succeeding

vowel. Further evidence that rising pitch cannot be said to be a uniform cue for stress is that both stressed and unstressed [i] and [ə] are observed to have rising pitch, while the stressed ['o] and ['u] have only level pitch. Also, both stressed and unstressed [a] and [o] occurring in the second syllable usually have falling pitch; occasionally they have level pitch. Information on duration, on the other hand, is straightforward and unambiguous and all the stress pairs can be differentiated on the basis of duration.

5.4.3. Conclusion

Much more detailed investigation needs to be made in order to arrive at definitive statements on the acoustic parameters of word stress in Maithili. Nevertheless, of the three parameters investigated in this limited study, duration appears to be the single most important cue. Relative intensity in itself offers little cue to stress in Maithili. Probably, a combination of duration and fundamental frequency might be considered as satisfactory acoustic correlates to stress in Maithili. Or, perhaps, the three acoustic features (duration, fundamental frequency and relative intensity in that order) collectively may be associated with what might be termed "stress" in Maithili.

REFERENCES

Abramson,A.S. 1976. Laryngeal Timing in Consonant Distinctions. *Haskins Laboratories Status Report on Speech Research:* 47, 105-112. Also in Fant,G. and Scully,C. (eds.) *The Larynx and Language, Phonetica* 34:4. 1977.

Ahmed,R. and Agrawal,S.S. 1969. Significant Features in the Perception of (Hindi) Consonants. *J. Acous. Soc. Am.:* 45, 758-763.

Allen,W.S. 1953. *Phonetics in Ancient India,* London: Oxford University Press.

Beames,J. 1872-79/reprint 1966. *A comparative Grammar of the Modern Aryan Languages of India.* (Three volumes now published in one format). Delhi: Munshiram Manohar-lal.

Belasco,S. 1953. The Influence of Force of Articulation of Consonants on Vowel Duration. *J. Acous. Soc. Am.* 25:5, 1015-1016.

Benguerel,A.P., Hirose,H., Sawashima,M. and Ushijima,T. 1977. Velar Coarticulation in French: A Fiberoptic Study. *Journal of Phonetics* 5:2.

——— 1978. Laryngeal Control in French Stop Production: A Fiberscopic, Acoustic and Electromyographic Study. *Folia phoniatrica* 30:3, 175-198.

Bhatia,T.K. 1973. A Computational Investigation on the Perception of Aspirated Consonants in Hindi. *Studies in Linguistic Sciences:* 8, 63-80.

——— 1976. On the Predictive Role of the Recent Theories of Aspiration. *Phonetica* 33:1, 62-74.

Bjuggren,G. 1960. Device for Laryngeal Phase-Determinable Flash Photography. *Folia phoniatrica* 12:1, 36-41.

Carré,R. 1975. Acoustic Characteristics of Vowel Nasalization. *Quarterly Progress Report* (RLE, M.I.T.): 105, 270-274.

Catford,J.C. 1964. Phonation Types: The Classification of Some Laryngeal Components of Speech Production, in Abercrombie,D. et al.(eds.) *In Honour of Daniel Jones.* Longmans, 26-37. 1964.

——— 1977. *Fundamental Problems in Phonetics,* Bloomington: Indiana University Press.

Chatterji,S.K. 1926. *The Origin and Development of the Bengali Language,* Calcutta: Calcutta University Press/Michigan: University Microfilms Reprints.

——— and Misra,B. (eds.) 1940. *Varṇa-Ratnâkara,* Bibliotheca Indica: 262, Calcutta: Royal Asiatic Society of Bengal.

Chen,M. 1970. Vowel Length Variation as a Function of Voicing of the Consonant Environment. *Phonetica* 22:3, 129-159.

Chomsky,N. and Halle,M. 1968. *The Sound Pattern of English*, New York: Harper and Row.

Cooper,F.S., Abramson,A.S., Sawashima,M. and Lisker,L. 1971. Looking at the Larynx During Running Speech. *Annals of Otology, Rhinology and Laryngology*, 80:5,678-682.

Dave,R. 1977. Studies in Gujarati Phonology and Phonetics. Unpublished Doctoral Dissertation, Cornell University.

Davis,A. 1973. Maithili Sentences, in Hale,A. (ed.) *Clause, Sentence and Discourse Patterns in Selected Languages of Nepal:* 1, 259-319. Kathmandu: Summer Institute of Linguistics, Tribhuvan University.

Delattre,P. 1951: The Physiological Interpretation of Sound Spectrograms. *PMLA* lxvi: 5, 864-875.

—— 1954. Les Attributs Acoustiques de la Nasalité Vocalique et Consonantique. *Studia Linguistica:* 8, 103-109.

—— 1962. Some Factors of Vowel Duration and Their Cross-Linguistic Validity. *J. Acous. Soc. Am.* 34:8, 1141-1143.

—— 1965. *Comparing the Phonetic Features of English, German, Spanish and French.* Heidelberg: Julius Gross Verlag.

DeVreese,K. 1962. Review of *The Formation of the Maithilī Language* by Subhadra Jha. 1958. *Journal of the American Oriental Society* 82:3, 402-406.

Dickson,D.R. and Maue,W.M. 1970. *Human Vocal Anatomy*, Springfield, Illinois: Charles C. Thomas.

Dixit,R.P. 1975. Neuromuscular Aspects of Laryngeal Control: With Special Reference to Hindi. Unpublished Doctoral Dissertation, University of Texas at Austin.

—— and Brown,W.S. Jr. 1978. Peak Magnitudes of Supraglottal Air Pressure Associated with Affricated and Nonaffricated Stop Consonant Productions in Hindi. *Journal of Phonetics.* 6:4, 353-365.

Fairbanks,G., House,A.S. and Stevens,E.L. 1950. An Experimental Study of Vowel Intensities. *J. Acous. Soc. Am.* 22:4, 457-459.

Fant,G. 1960. *Acoustic Theory of Speech Production.* Mouton: The Hague.

—— 1973. *Speech Sounds and Features.* Massachusetts: The M.I.T. Press.

Ferguson,C.A., Hyman,L.M. and Ohala,J.J. (eds.) *Nasálfest: Papers from a Symposium on Nasals and Nasalization.* Stanford: Language Universals Project, 1975.

Fischer-Jorgensen,E. 1964. Sound Duration and the Place of Artic-

ulation. *Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung* 17:2-4, 175-207.

Fry,D.B. 1955. Duration and Intensity as Physical Correlates of Linguistic Stress. *J. Acous. Soc. Am.:* 27, 765-768.

——— 1958. Experiments in the Perception of Stress. *Language and Speech:* 1, 126-152.

——— 1965. The Dependence of Stress Judgments on Vowel Formant Structure. In Zwirner,E. and Bethge,W. (eds.) *Proceedings of the 6th International Congress of Phonetic Sciences.* Karger, 306-311.

——— (ed.) *Acoustic Phonetics: A Course of Basic Readings.* London: Cambridge University Press. 1976.

Fónagy,I. 1966. Electro-Physical and Acoustic Correlates of Stress and Stress Perception. *Journal of Speech and Hearing Research:* 9, 231-244.

Fujimura,O. 1960. Spectra of Nasalized Vowels. *Quarterly Progress Report* (RLE, M.I.T.):58, 214-218.

Gay,T. 1978a. Effect of Speaking Rate on Vowel Formant Movements. *J. Acous. Soc. Am.* 63, 223-230.

——— 1978b. Physiological and Acoustic Correlates of Perceived Stress. *Language and Speech* 21:4, 347-353.

Grierson,G.A. 1881. *An Introduction to the Maithilî Language of North Bihár,* Part I. Grammar, Calcutta: Asiatic Society of Bengal.

——— 1882. *An Introduction to the Maithilî Language of North Bihár,* Part II. Chrestomathy and Vocabulary, Calcutta: Asiatic Society of Bengal.

——— 1883a. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language,* Part I. Introductory, Calcutta: Bengal Secretariat Press.

——— 1883b. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language,* Part III. Magadhi Dialect of South Patna and Gaya. Calcutta: Bengal Secretariat Press.

——— 1883c. Essays on Bihárî Declension and Conjugation. *Journal of the Asiatic Society of Bengal:* Lii, Part I, No.II, 119-159.

——— 1884a. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language,* Part II, Bhojpurî Dialect. Calcutta: Bengal Secretariat Press.

——— 1884b. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language,* Part IV. Maithil-Bhojpurí Dialect. Calcutta: Bengal Secretariat Press.

——— 1885. *Seven Grammars of the Dialects and Subdialects of the*

Bihárî Language. Part V. South Maithilí Dialect. Calcutta: Bengal Secretariat Press.

—— 1886. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language*. Part VI. South-Maithili-Magadhi Dialect. Calcutta: Bengal Secretariat Press.

—— 1887a. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language*. Part VII. South Maithilí-Bangálí Dialect of South Bhagalpúr. Calcutta: Bengal Secretariat Press.

—— 1887b. *Seven Grammars of the Dialects and Subdialects of the Bihárî Language*. Part VIII. Maithili-Bangali Dialect. Calcutta: Bengal Secretariat Press.

—— 1895a. On the Stress Accent in the Modern Indo-Aryan Vernaculars. *Journal of the Royal Asiatic Society of Great Britain and Ireland*. Series 2, Vol.27, 139-147.

—— 1895b. On the Phonology of the Modern Indo-Aryan Vernaculars. *Zeitschrift der Deutschen Morgenländischen Gesellschaft:* 49, 393-421.

—— 1896. On the Phonology of the Modern Indo-Aryan Vernaculars. *Zeitschrift der Deutschen Morgenländischen Gesellschaft:* 50, 1-42.

—— 1903/reprint 1968. *Linguistic Survey of India* 5:2. India: Motilal Banarsidas.

—— 1918. Indo-Aryan Vernaculars. *BSOS*. 1:2, 47-81.

—— 1919. Indo-Aryan Vernaculars. *BSOS*. 1:3, 51-85.

—— 1927/reprint 1967. *Linguistic Survey of India* 1:1. India: Motilal Banarsidas.

Gupta,J.P., Agrawal,S.S. and Ahmed,R. 1969. Perception of (Hindi) Consonants in Clipped Speech. *J. Acous. Soc. Am.* 45:3, 770-773.

—— and Ahmad,A. 1975. Perception of (Hindi) Consonants in Differenciated Clipped Speech. *J. Acous. Soc. Am.* 58:1, 282-283.

Halle,M. 1973. Review of *Preliminaries to Linguistic Phonetics*, by P.Ladefoged. *Language* 49:4, 926-933.

—— and Stevens,K.N. 1967. On the Mechanism of Glottal Vibration for Vowels and Consonants. *Quarterly Progress Report* (RLE, M.I.T.):85, 267-270.

Harshman,R., Ladefoged,P. and Goldstein,L. 1977. Factor Analysis of Tongue Shapes. *J. Acous. Soc. Am.* 62:3, 693-707.

Harris,K.S. 1970. Physiological Measures of Speech, Movements: EMG and Fiberoptic Studies. *American Speech and Hearing Association Report:* 5, 271-282.

Harris,K.S. 1971. Vowel Stress and Articulatory Reorganization. *Haskins Laboratories Status Report on Speech Research:* 28, 167-178.

Henderson,M.M.T. 1976. Redundancy, Markedness, and Simultaneous Constraints in Phonology. *Language* 52:2, 314-325.

Hirose,H., Lisker,L. and Abramson,A.S. 1972. Physiological Aspects of Certain Laryngeal Features in Stop Production. *Haskins Laboratories Status Report on Speech Research* 31/32, 183-191.

——, Lee,C.Y. and Ushijima,T. 1974. Laryngeal Control in Korean Stop Production. *Journal of Phonetics* 2:2, 145-152.

Hoernle,A.F.R. 1880. *A Comparative Grammar of the Gaudian Languages.* London: Trübner and Company.

—— and Grierson,G.A. 1885. *A Comparative Dictionary of the Bihārī Language,* Part I. Calcutta: Bengal Secretariat Press.

—— 1889. *A Comparative Dictionary of the Bihārī Language,* Part II. Calcutta: Bengal Secretariat Press.

Hollien,H. 1964/1965. Stroboscopic Laminagraphy of the Vocal Folds. *Proceedings of the 5th International Congress of Phonetic Sciences.* Basel, New York: S.Karger 1965, 362-364.

House,A.S. 1957. Analog Studies of Nasal Consonants. *Journal of Speech and Hearing Disorders* 22:2, 190-204.

—— 1961. On Vowel Duration in English. *J. Acous. Soc. Am.* 33, 1174-1177.

—— and Fairbanks,G. 1953. The Influence of Consonant Environment Upon the Secondary Acoustical Characteristic of Vowels. *J. Acous. Soc. Am.* 25, 105-113.

—— and Stevens,K.N. 1956. Analog Studies of the Nasalization of Vowels. *Journal of Speech and Hearing Disorders* 21:2,218-232.

Hyman,L.M. (ed.) *Studies in Stress and Accent.* Los Angeles: Southern California Occasional Papers in Linguistics No.4, 1977.

Ingemann,F. and Yadav,R. 1978. Voiced Aspirated Consonants, in Lance,D.M. and Gulstad,D.E. (eds.) *Papers from the 1977 Mid-America Linguistics Conference.* Columbia, Missouri: University of Missouri, 337-344.

Iwata,R. and Hirose,H. 1976. Fiberoptic Acoustic Studies of Mandarin Stops and Affricates. *Annual Bulletin: Research Institute of Logopedics and Phoniatrics.* Tokyo, 10, 47-60.

Jeffers,R.J. 1976. The Position of the Bihārī Dialects in Indo-Aryan. *Indo-Iranian Journal* 18:3-4, 215-225.

Jensen,O.K. 1967. Features of the Acoustical and Physiological Structure of the French Nasal Vowels. *Annual Report, Institut*

for Fonetik Universitet Copenhagen 1, 59-66.

Jha,D. 1950/B.S.2008. *Mithila Bhasha Kosh* (Maithili Dictionary), Patna (India): Sri Rambhajan Press. (in Maithili).

Jha,G. 1974. *Maithilī Bhāshākā Vikās* (The Development of the Maithili Language). Patna (India): Bihar Hindi Granth Academy. (in Hindi).

Jha,R. 1971. *Origin and Development of Maithili Script*. Patna (India): Kalika Press. (in Maithili).

Jha,S. 1941. Maithili Phonetics. *Indian Linguistics* 8:1. Reprint edition Vol.II, 1965, 435-459.

—— 1958. *The Formation of the Maithilī Language*. London: Luzac and Co., Ltd.

Jha,Sh. 1957. A Bird's Eye View of the Maithili Language. *Journal of the Bihar Research Society* Vol.xliii, 67-73.

Jones,D. 1956. *An Outline of English Phonetics*. 8th edition, Cambridge: Heffer and Sons.

Jones,S. 1929. Radiography and Pronunciation. *British Journal of Radiology* 2, 149-150.

Kagaya,R. 1971. Laryngeal Gestures in Korean Stop Consonants. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics*. Tokyo, 5, 15-23.

—— 1974. A Fiberscopic and Acoustic Study of the Korean Stops, Affricates and Fricatives. *Journal of Phonetics* 2:2, 161-180.

Kagaya,R. and Hirose,H. 1975. Fiberoptic, Electromyographic and Acoustic Analyses of Hindi Stop Consonants. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics*. Tokyo:9,27-46.

Kellogg,S.H. 1893. *A Grammar of the Hindi Language*. Second Edition. London: Routledge and Kegan Paul, Ltd.

Kim,C-W. 1965. On the Autonomy of the Tensity Feature in Stop Classification. *Word* 21:3, 339-359.

—— 1967. Cineradiographic Study of Korean Stop and a Note on "Aspiration". *Quarterly Progress Report* (RLE, M.I.T.): 86, 259-272.

—— 1970. A Theory of Aspiration. *Phonetica* 21:2, 107-116.

Kjellin,O. 1977. Observations on Consonant Types and "Tone" in Tibetan. *Journal of Phonetics* 5:4, 317-338.

Klatt,D.H. 1976. Linguistic Uses of Segmental Durations in English: Acoustic and Perceptual Evidence. *J. Acous. Soc. Am.* 59:5, 1208-1221.

Ladefoged,P. 1956. The Classification of Vowels. *Lingua* 5:2, 113-127.

—— 1959. The Perception of Vowel Sounds. Unpublished Ph.D. Thesis, University of Edinburgh.

Ladefoged,P. 1962. *Elements of Acoustic Phonetics.* Chicago: The University of Chicago Press.

—— 1967. *Three Areas of Experimental Phonetics.* London: Oxford University Press.

—— 1971. *Preliminaries to Linguistic Phonetics.* Chicago: The University of Chicago Press.

—— 1973. The Features of the Larynx. *Journal of Phonetics* 1:1, 73-83.

—— 1974. Respiration, Laryngeal Activity and Linguistics. In Wyke,B.D. (ed.) *Proceedings of the International Symposium on Ventilatory and Phonatory Control Systems.* Oxford University Press. 1974. 299-314.

—— 1975. *A Course in Phonetics.* New York: Harcourt Brace Jovanovich.

—— 1976. The Stops of Owerri Igbo. *Studies in African Linguistics.* Supplement, 6,147-163.

—— 1979. What are Linguistic Sounds Made Of? *U.C.L.A. Working Papers in Phonetics* 45, 1-24.

——, DeClerk,J.L. and Harshman,R. 1972. Control of the Tongue in Vowels. In Regault,A. and Charbonneau,R. (eds.) *Proceedings of the 7th International Congress of Phonetic Sciences* Mouton: The Hague. 1972. 349-354.

Lehiste,I. 1961. Some Acoustic Correlates of Accent in Serbo-Croation. *Phonetica* 7, 114-147.

—— (ed.) *Readings in Acoustic Phonetics.* Massachusetts, The M.I.T. Press. 1967.

—— 1970. *Suprasegmental.* Cambridge: The M.I.T. Press.

Lieberman,P. 1960. Some Acoustic Correlates of Word Stress in American English. *J. Acous. Soc. Am.* 32, 23-44.

—— 1967. *Intonation, Perception, and Language.* Research Monograph No.38. Massachusetts: The M.I.T. Press.

Lindau,M. 1978. Vowel Features. *Language* 54:3, 541-563.

Lindblom,B. 1962. Accuracy and Limitations of Sona-Graph Measurements. In Sovijarvia,A. and Aalto,P. (eds.) *Proceedings of the Fourth International Congress of Phonetic Sciences.* Mouton: The Hague. 1962. 188-202.

Lindbloom,B. 1963. Spectrographic Study of Vowel Reduction. *J. Acous. Soc. Am.*: 35, 1773-1781.

Lisker,L. 1974. On 'Explaining' Vowel Duration Variation. *Glossa* 8:2, 233-246.

Lisker,L. and Abramson,A.S. 1964. A Cross-Language Study of Voicing in Initial Stops: Acoustical Measurements. *Word* 20:3, 384-422.

—— 1972. Glottal Modes in Consonant Distinctions. In Rigault,A. and Charbouneau,R. (eds.) *Proceedings of the seventh International Congress of Phonetic Sciences*. Mouton: The Hague,1972 366-370.

Lisker,L., Sawashima,M., Abramson,A.S. and Cooper,F.S. 1970. Cinegraphic Observations of the Larynx During Voiced and Voiceless Stops. *Haskins Laboratories Status Report on Speech Research* 21/22, 201-210.

Maddieson,I. 1977. Further Studies on Vowel Length Before Aspirated Consonants. *UCLA Working Papers in Phonetics* 38, 82-90.

—— and Gandour,J. 1976. Vowel Length Before Aspirated Consonants. *UCLA Working Papers in Phonetics* 31, 46-52.

Malmberg,B. (ed.) *Manual of Phonetics*. 1968. Amsterdam: North--Holland Publishing Company.

Matsushita,H. 1975. The Vibratory Mode of the Vocal Folds in the Excised Larynx. *Folia Phoniatrica* 27, 7-18.

Mishra,J. 1949. *A History of the Maithili Literature* Vol.1. Allahabad (India): Tirbhukti Publications.

—— 1969a. *A History of the Maithili Literature* Vol.2. Allahabad (India): Tirbhukti Publications.

—— 1969b. The Case of Maithili. In *Language and Society in India:* Transactions of Indian Institute of Advanced Study. Simla: IIAS. Vol.8, 266-275.

Mittal,L.N. and Gupta,J.P. 1971. A Preliminary Study on the Formant Frequencies of Hindi Vowels. *Gaveṣaṇa* 17, 129-130.

Morton,J. and Jassem,W. 1965. Acoustic Correlates of Stress. *Language and Speech* 8, 159-181.

Nihalani,P. 1974. An Aerodynamic Study of Stops in Sindhi. *Phonetica* 29:3, 193-224.

—— 1975a. Air Flow Rate in the Production of Stops in Sindhi. *Phonetica* 31, 198-205.

—— 1975b. Velopharyngeal Opening in the Formation of Voiced Stops in Sindhi. *Phonetica* 32:2, 89-102.

Niimi,S. and Sawashima,M. 1974. A Preliminary Study on the Simultaneous Recording of Laryngeal Muscle Activities and the Glottal Shape During Running Speech Utterance. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics.* Tokyo:8, 19-22.

Ohala,J. 1975. Phonetic Explanations for Nasal Sound Patterns. In Ferguson,C.A., Hyman,L.M., and Ohala,J. (eds.). 1975. 289-316.

——— 1977. The Physiology of Stress. In Hyman,L.M. (ed.). 1977. 145-168.

——— and Ohala,M. 1972. The Problem of Aspiration in Hindi Phonetics. *University of California, Berkeley: POLA Series* 2:16, 63-70.

Ohala,M. 1972. Topics in Hindi-Urdu Phonology. Unpublished Doctoral Dissertation, University of California, Los Angeles.

——— 1975. Nasals and Nasalization in Hindi. In Ferguson,C.A., Hyman,L.M. and Ohala,J.J. (eds.). 1975. 317-332.

——— 1977. Stress in Hindi. In Hyman,L.M. (ed.) *Studies in Stress and Accent, Los Angeles: Southern California Occasional Papers in Linguistics* No.4, 327-338.

Pathak,R.S. 1976. Nasalization in Bagheli: An Electrokymographic Study. *Indian Linguistics* 37:4, 312-315.

Perkell,J.J. 1969. *Physiology of Speech Production: Results and Implications of a Quantitative Cineradiographic Study.* Research Monograph No.53, Massachusetts: The M.I.T. Press.

Peterson,G.E. 1951. The Phonetic Value of Vowels. *Language* 27:4, 541-553.

——— 1959. Vowel Formant Measurements. *Journal of Speech and Hearing Research* 2:2, 173-183.

——— and Barney,H.L. 1952. Control Methods Used in a Study of the Vowels. *J. Acous. Soc. Am.* 24, 175-184.

——— and Lehiste,I. 1960. Duration of Syllable Nuclei in English. *J. Acous. Soc. Am.* 32, 693-703.

Pressman,J.J. and Kelemen,G. 1955. Physiology of the Larynx. *Physiological Reviews* 35:3, 506-554.

Rothenberg,M. 1968. *The Breath-Stream Dynamics of Simple-Released-Plosive Production, Bibliotheca Phonetica,* No.6.

Royal Nepal Academy 1973-74/B.S.2030. *Parayāyavācī Savdakoś* (Dictionary of Synonyms), Kathmandu. (in Nepali).

Saito,S., Fukuda,H., Kitahara,S. and Kokawa,N. 1978. Stroboscop-

ic Observation of Vocal Fold Vibration with Fiberoptics. *Folia phoniatrica* 30:4, 241-244.

Sawashima,M. 1968. Movement of the Larynx in Articulation of Japanese Consonants. *Annual Bulletin, Institute of Logopedics and Phoniatrics*. Tokyo. 2. 11-20.

Sawashima,M. 1977. Fiberoptic Observation of the Larynx and Other Speech Organs. In Sawashima,M. and Cooper,F.S. (eds.), 1977. 31-46.

—— and Cooper,F.S. (eds.). *Dynamic Aspects of Speech Production*. Tokyo: University of Tokyo Press. 1977.

—— and Hirose,H. 1968. New Laryngoscopic Technique by Use of Fiber Optics. *J. Acous. Soc. Am.* 43:1, 168-169.

—— and Miyazaki,S. 1973. Glottal Opening for Japanese Voiceless Consonants. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics*. Tokyo. 7.

—— and Niimi,S. 1974. Laryngeal Conditions in Articulations of Japanese Voiceless Consonants. *Annual Bulletin, Research Institute of Logopedics and Phoniatrics*. Tokyo. 8. 13-17.

——, Abramson,A.S., Cooper,F.S. and Lisker,L. 1970. Observing Laryngeal Adjustments During Running Speech by Use of a Fiberoptics System. *Phonetica* 22, 193-201.

Sen,A.C. 1935. An Experimental Study of Bengali Occlusives. *Proceedings of the Second International Congress of Phonetic Sciences*. London. 1936. 184-193.

Smith,S. 1954. Remarks on the Physiology of the Vibrations of the Vocal Cords. *Folia Phoniatrica* 6, 166-178.

Sonesson,B. 1958. The Functional Anatomy of the Speech Organs. In Malmberg,B. (ed.) 1958. 45-75.

—— 1959. A Method for Studying the Vibratory Movements of the Vocal Cords -- A Preliminary Report. *Journal of Laryngology* 73, 732-737.

Southworth,F.C. 1961. Review of *The Formation of the Maithilī Language*, by S.Jha. 1958. *Language* 37:1, 168-173.

Tanabe,M., Kitajima,K., Gould,W.J. and Lambiase,A. 1975. Analysis of High-Speed Motion Pictures of the Vocal Folds. *Folia phoniatrica* 27:2, 77-87.

——, Kitajima,K. and Gould,W.J. 1975. Computer Analysis of High-Speed Motion Pictures of the Vocal Folds Vibrations. *Studia Phonologica*. Tokyo: Institute for Phonetic Sciences, 9, 33-39.

Timcke,R., Von Leden,H. and Moore,P. 1958. Laryngeal Vibrations: Measurements of the Glottic Wave, Part I, The Normal Vibrato-

ry Cycle. *A.M.A. Archives of Otolaryngology* 68, 1-19.

—— 1959. Laryngeal Vibrations: Measurements of the Glottic Wave, Part II - Physiological Variations. *A.M.A. Archives of Otolaryngology* 69, 64/438-70/444.

Trail,R.L. 1973. *Words Lists*. Kathmandu: SIL, Tribhuvan University.

Umeda,N. 1975. Vowel Duration in American English. *J. Acous. Soc. Am.* 58:2, 434-445.

Van den Berg,J. 1958. Myoelastic-Aerodynamic Theory of Voice Production. *Journal of Speech and Hearing Research* 1:3. 227-244.

Varma,S. 1929/1961. *Critical Studies in the Phonetic Observations of Indian Grammarians*. London: Royal Asiatic Society. Reprinted 1961, Delhi: Munshi Ram Manohar Lal.

Velayudhan,S. 1971. *Vowel Duration in Malayalam: An Acoustic Phonetic Study*. Monograph No.1, Trivandrum, Dravidian Linguistic Association of India.

—— and Howie,J.M. 1974. Acoustical Measurements of Distinctive, Vowel Quantity in Malayalam. *Language and Speech* 17:1, 95-101.

von Leden,H., Moore,P. and Timcke,R. 1960. Laryngeal Vibrations: Measurements of the Glottic Wave, Part III - The Pathologic Larynx. *A.M.A. Archives of Otolaryngology* 71, 26/16-45/35.

Williams,J. 1973. Clause Patterns in Maithili. In Trail,R.L. (ed.) *Patterns in Clause, Sentence and Discourse in Selected Languages of India and Nepal* 2, 1973. 345-352. Kathmandu: SIL, Tribhuvan University.

Yadav,R. 1976. Generative Phonology and the Aspirated Consonants of Colloquial Maithili. *Contributions to Nepalese Studies* 4:1, 77-91.

—— 1977. Language, Linguistics and Politics: Some Implications for Language Policy in Nepal. Paper presented at the 39th Summer Meeting of the Linguistic Society of America, Honolulu, Hawaii. (Also deals with the status of Maithili as a language in Nepal).

—— 1979. The Influence of Aspiration on Vowel Duration in Maithili. *South Asian Languages Analysis*. (Illinois: Urbana Champaign) 1:1, 157-165.

—— 1979. A Fiberoptic Study of Stop Production in Maithili. *Kansas Working Papers in Linguistics* 4:2, 55-69.

Zimmerman,S.A. and Sapon,S.M. 1958. Note on Vowel Duration Seen Cross-Linguistically. *J. Acous. Soc. Am.* 30:2, 152-153.